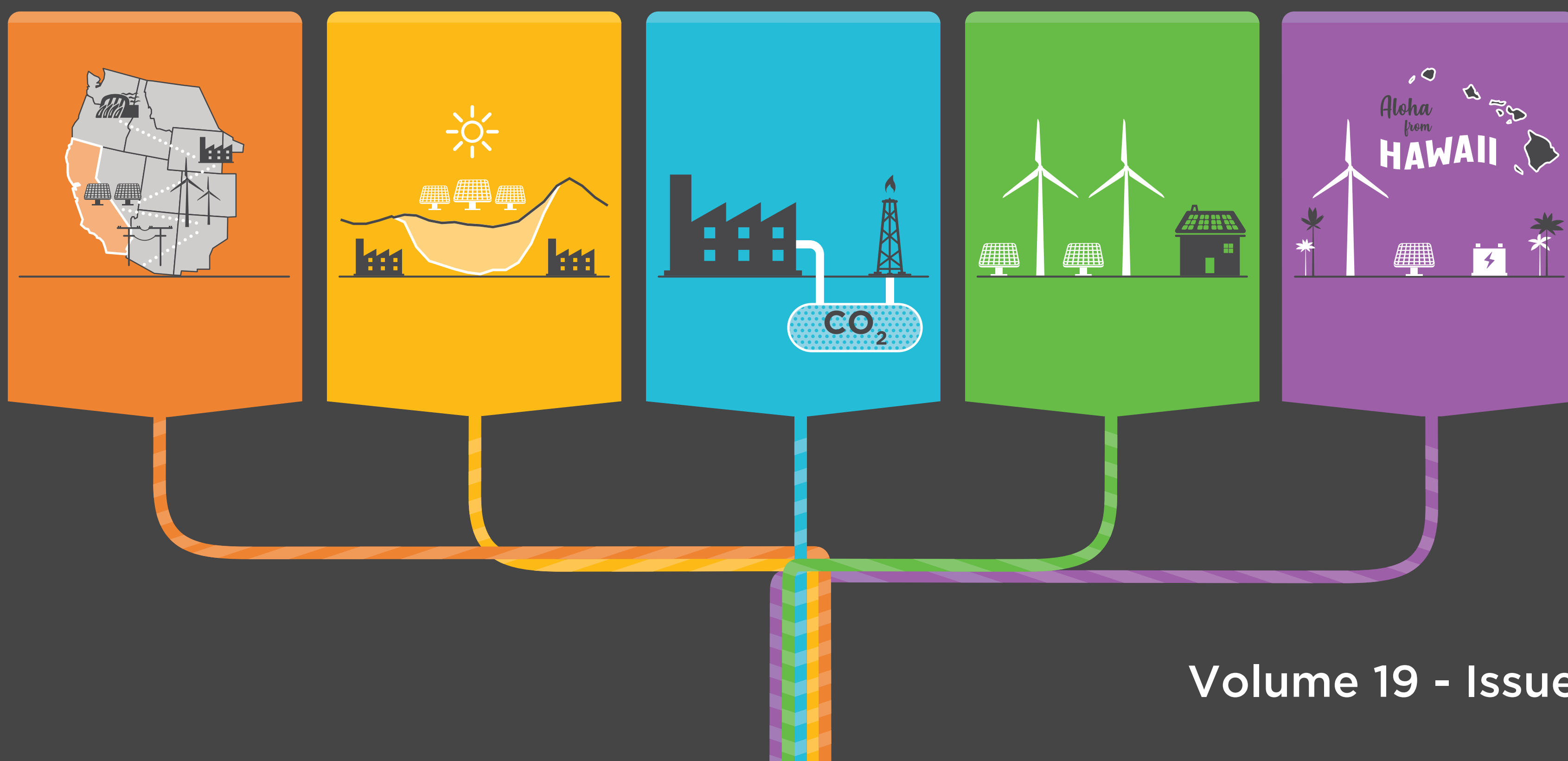
THE SCOTTMADDEN ENERGY INDUSTRY UPDATE

EVERYTHING COUNTS ... IN LARGE AMOUNTS



Volume 19 - Issue 2

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EXECUTIVE SUMMARY
EVERYTHING COUNTS ... IN LARGE AMOUNTS

So how does a lyric from one of Depeche Mode's greatest hits apply to the energy industry? In the United States, as well as worldwide, there is continued and accelerating interest in the reduction of greenhouse gas (GHG) emissions. Significantly reducing GHGs will be challenging and the complete decarbonization that some advocate, even more so. Technology and the new resources being placed on the grid are moving toward cleaner, lower-emitting sources. But policymakers and industry leaders concede it will require a wide variety of methods and resources to approach the ambitious clean energy and decarbonization targets states and utilities are setting. Increasingly, "everything counts in large amounts," as well as in small ones, which can aggregate or grow to provide meaningful emissions reduction.

Some Highlights of This ScottMadden Energy Industry Update	
EVERYTHING COUNTS ...	▪ With continued global development of fossil-fired power plants, many believe the power industry needs to revisit approaches, such as carbon capture, utilization, and storage, which aid in reducing GHG emissions from these plants. But development lags and technology costs must be considered. However, technologies such as NETPower's Allam cycle plant, which represents a new, potentially breakthrough approach, are being tested. ▪ Hawaii was an early adopter of aggressive clean targets, aiming for 40% renewable energy by 2030 and a full 100% by 2045. It is encouraging utilities to take a holistic view of grid needs in light of these aspirations and is tying together the elements of a grid evolution—grid modernization, transportation electrification, renewables procurement, and performance-based ratemaking, among other things—into an integrated process in which "everything counts" for planning.
... IN LARGE AMOUNTS	▪ Not only is the California ISO's Western Energy Imbalance Market providing opportunities for western U.S. utilities to optimize their resources and mitigate effects of the ever-growing California duck curve, but now another such market has also been proposed. These energy imbalance markets are intended to increase the availability of clean power across the West and provide much-needed ramping capability. Although these markets do not yet exist in "large amounts," they are growing and "count" toward clean energy aspirations. ▪ Different state policy regimes are encouraging higher renewable energy penetration. But not all renewables are created equal and there are differences between utility-scale and distributed resources. Depending upon current levels of penetration and customer preferences, "large amounts" of utility-scale resources may be preferable to smaller, distributed resources. ▪ Finally, solar resource penetration in California has been growing. While the California grid operator had predicted the duck curve with its potential impact on net load and late-day energy needs at certain times of the year, these "large amounts" of wind and solar energy have generated a much deeper "belly" of the curve sooner than projected, posing potential challenges for the grid operator.

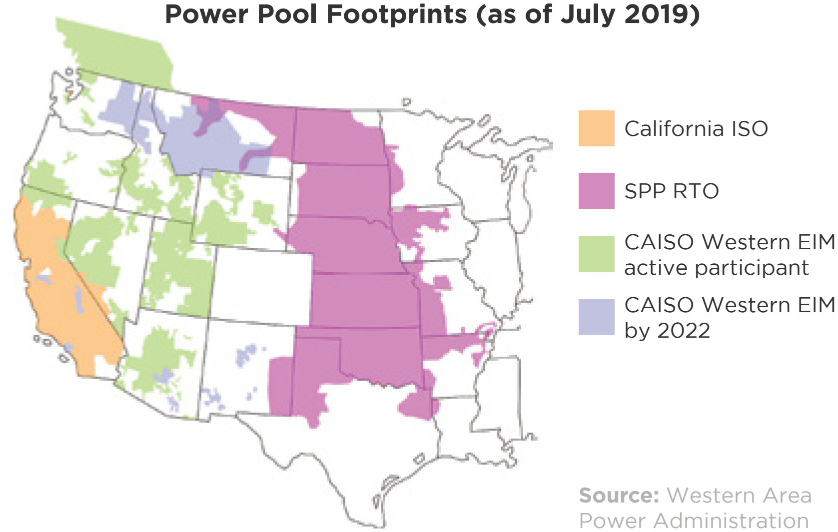
WESTERN ENERGY IMBALANCE MARKETS
MARKETS TO OPTIMIZE RESOURCES

California ISO's Western Energy Imbalance Market continues to grow as an alternative service vies for participants.

What Is an Energy Imbalance Market?

- In the North American power system, balancing authorities (BAs) are responsible for balancing the real-time supply and demand for power typically from resources within their geographic footprint. Energy imbalance is the difference in real time between scheduled power flows and the energy needed to meet demand arising from unexpected differences in resource output and availability, transmission constraints, or demand.
- While the relative total transaction value in an imbalance market in real-time costs is small compared to total wholesale power revenues, these markets will become increasingly important with higher penetrations of variable energy resources.
- In the western United States, an energy imbalance market has been in place for several years, driven by changes in California's generation mix and renewable portfolio standard, as well as GHG reduction targets and the retirement of once-through cooled plants.

Western Energy Imbalance Markets and Southwest Power Pool Footprints (as of July 2019)

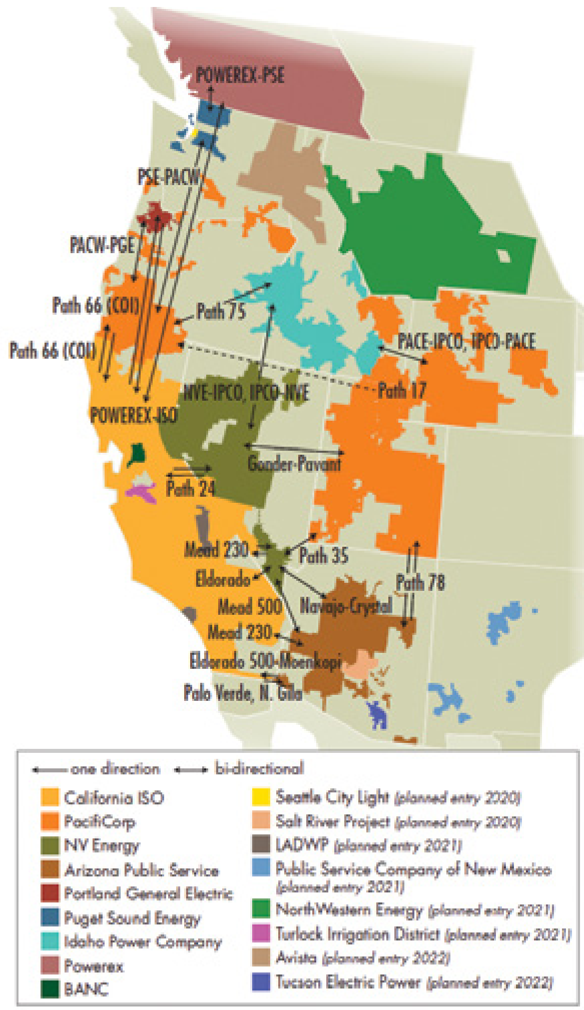


Source: Western Area Power Administration

Western EIM: Linking Markets

- The western U.S. electricity market consists of diverse resources arrayed over a large geographic area. Power flows are dominated by California demand, (over)supply from renewables in localized areas at certain times of the day or year, and normally abundant hydroelectric power in the Pacific Northwest, with thermal and renewable generation throughout the rest of the footprint.
- In late 2014, the CAISO formed an energy imbalance market (EIM), the first in the West open to non-RTO members. CAISO's Western EIM is intended to link BAs, allow for a broader set of diverse resources for buyers and sellers of imbalance energy, and better integrate wind and solar resources, providing markets for their production in lieu of curtailment during high output and lower net load conditions. The Western EIM takes advantage of unused sub-hourly transmission capacity to move imbalance power between BAs.
- The Western EIM has grown from being just a handful of BAs adjacent to CAISO when it was initially formed to occupying a much broader

Estimated Maximum Transmission Transfer Capacity (EIM Entities Operating in Q2 2019)



Path	Estimated Max Capacity (MW)
Path 24 (west to east)	100
Path 24 (east to west)	35-90
Eldorado	797
Path 35 (west to east)	580
Path 35 (east to west)	538
Gonder-Pavant	130
PACW to PGE	320
Path 66 (ISO to PGE)	627
Path 66 (PGE to ISO)	296
Path 66 (ISO to PACW)	331
Path 66 (PACW to ISO)	432
Path 17	0-400[1] [2]
PSE to PACW	300
Eldorado 500-Moenkopi	732
Palo Verde, N. Gila	3,151
Path 78 (PACE to APS)	625
Path 78 (APS to PACE)	660
Navajo-Crystal	522
Mead 500	349
Mead 230 (APS <--> ISO)	236
Mead 230 (ISO to NVE)	3,443
Mead 230 (NVE to ISO)	3,476
IPCO to PACW (Path 75)	1,500
PACW to IPCO (Path 75)	400-510
PACE to IPCO	2,557
IPCO to PACE	1,550
NVE to IPCO	262
IPCO to NVE	390-478
Powerex <--> PSE	150
Powerex <--> ISO	150

[1] Is an optional path available for PACE-PACW EIM transfers and the capacity is a subset of PACE-IPCO/IPCO-PACE and Path 75 capacity.
[2] When in use, the available capacity on PACE-IPCO/IPCO-PACE and Path 75 will be subsequently reduced by the used amount on Path 17, and not double counted.

Current as of July 2019

Source: CAISO

KEY TAKEAWAYS

- **Expanding the market footprint by attracting non-RTO members to participate in such offerings as an EIM not only improves the integration and employment of renewables, but it also represents an important operational tool for CAISO and SPP, respectively.**
- **Entities connected to both SPP and CAISO will likely be analyzing—or reanalyzing—operational, policy, governance, and financial criteria regarding which energy imbalance market to join.**
- **Regulatory impacts are key considerations when contemplating market participation. Issues such as integrated resource planning mandates, required generation benefits for in-state customers, or changes in cost recovery for market expenses may drive consideration of market choice, no-regrets actions, and off-ramps.**

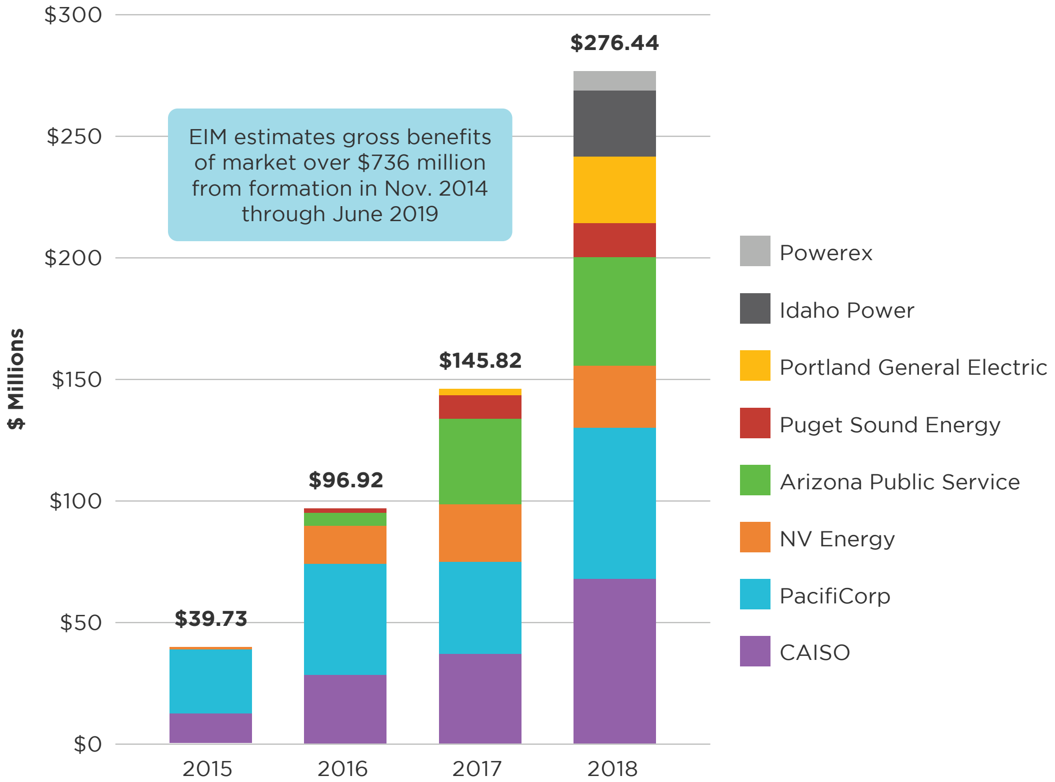
footprint today. This growth has created network effects within its footprint as it eased transmission transfer limitations and reduced congestion. The addition of Idaho Power to the Western EIM, along with the linkage of PacifiCorp's East and West regions, has allowed for power transfers in both clockwise and counterclockwise directions in the Western Interconnection.

- Although cost savings per megawatt-hour are relatively small compared to day-ahead energy costs, aggregate savings* are meaningful and increasing with expansion of the Western EIM (see chart). Moreover, benefits are above and beyond optimization of other wholesale costs and are visible and of interest to regulators, even appearing in rate cases sometimes. Finally, EIM transactions can help jurisdictions interested in reducing GHG to accomplish that objective.
- A key benefit is the reduction in curtailed renewable generation, with high exports from CAISO during midday hours, particularly in spring, and imports into California during morning and evening ramping hours, reflecting "duck curve" energy needs.

An Alternative from the East

- After having run an imbalance market for its members for a dozen years, in April 2019, the SPP proposed an energy imbalance service in the West (the Western Energy Imbalance Service or WEIS) to leverage the experience, systems, and infrastructure of the Integrated Marketplace it had launched in 2014.
- Interestingly, SPP is not in the Western Interconnection, although it has arrangements with the Public Service Company of Colorado under a joint dispatch agreement that, among other things, employs unused transmission capacity for moment-to-moment dispatch of all dispatchable resources on a least-cost basis. The Western Area Power Administration, itself a part of the Western Interconnection, has sold capacity and energy into the SPP market, leveraging favorable hydrological conditions to generate additional revenues.

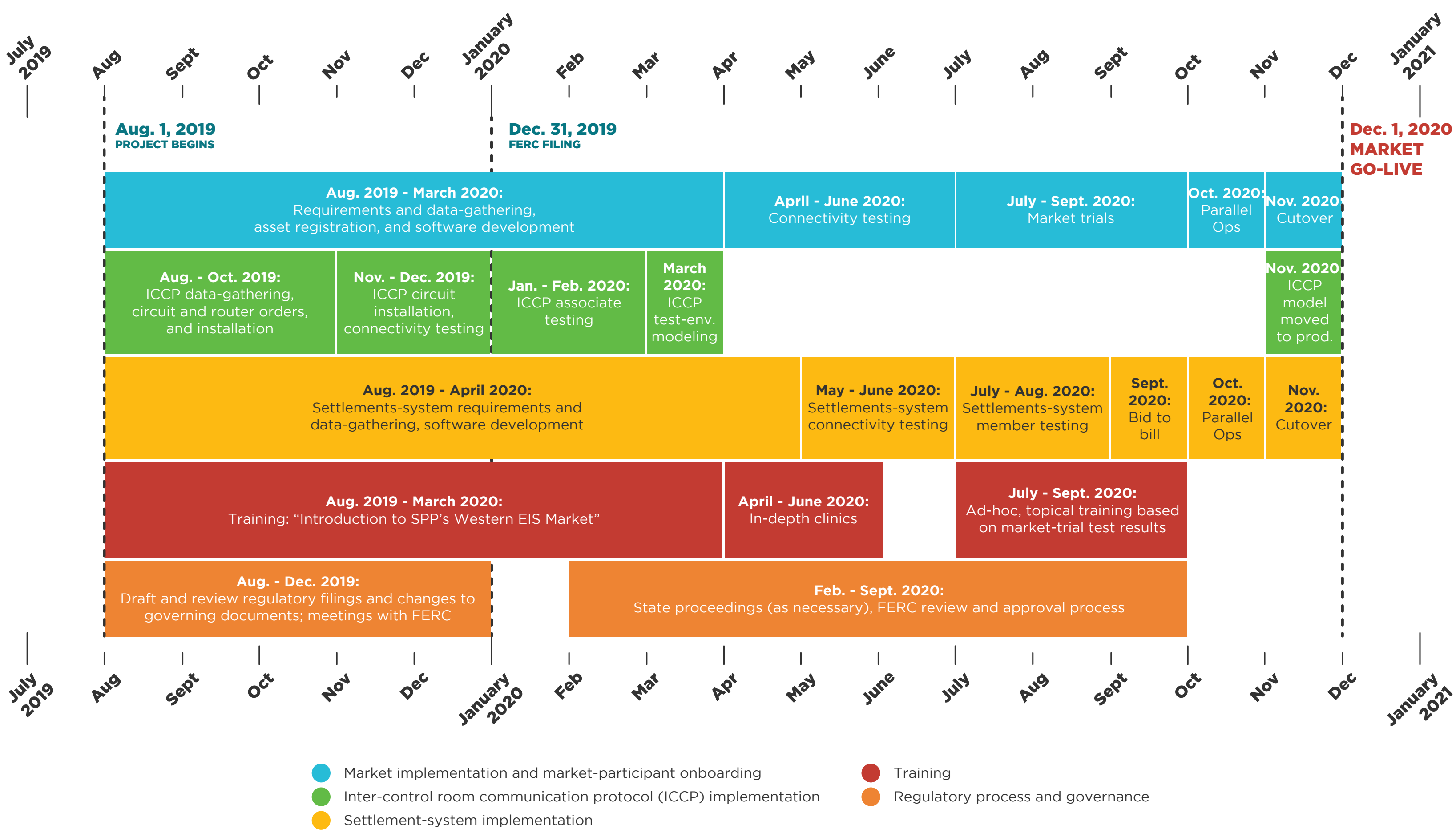
Western Energy Imbalance Market Total Gross Benefits and by Participant (2015–2018) (in $ Millions)



Source: CAISO

- The proposed WEIS is a five-minute, real-time, centrally dispatched imbalance market, with resources priced based upon locational marginal pricing using zero cost, "as available" transmission capacity. Like the Western EIM, WEIS allows participants to reduce costs through improved regional utilization and coordination of resources.
- In WEIS, dispatchable resources include controllable demand response and variable energy resources, although the ramp rates of the latter may not exceed 4% per minute—or 8 MWs/minute for resources of up to 200 MWs—of their maximum economic operating limit.
- Because WEIS is administered as a contractual arrangement, participants need not join SPP to engage in the market. SPP touts its "local" governance model as making it more accountable to stakeholders.
- SPP plans to get the market up and running by the end of 2020 (see graphic below).

Western Energy Imbalance Service Implementation Timeline



Source: SPP

- The West now has two ISOs offering imbalance market services. While many western utilities have planned to join the Western EIM, a number are still weighing their options.
- But deciding in which imbalance market to participate requires some evaluation criteria based upon market scope and products, governance, and other considerations (see table at right).

Considerations in Choosing an Imbalance Market

Area	Key Questions	Why It Matters
Governance Structure	▪ Who determines market structure and sets rules for the market, including any changes? ▪ Which stakeholders have a say and what are their decision rights?	▪ Because participants are ultimately dependent upon regulators for permission, governance must be responsive to their interests. ▪ For example, it may be difficult to effect certain changes through CAISO's board if its accountability is principally to California stakeholders. (Note: CAISO has proposed governance changes that afford the EIM member committee greater input.)
Cost and Ease of Participation	▪ What upfront and ongoing systems, processes, and staff expenses will be required? ▪ How long will it take to prepare for Day 1 of market participation?	▪ A drawn-out process with high upfront costs could mean a longer payback period for participation. ▪ Potential revenues from participation will need to be analyzed to determine costs vs. benefits. ▪ In some cases, preparing for participation could take a year or longer—a significant commitment of organizational attention and resources.
Diversity of Resources	▪ What energy resources are participating in the market and how do they compare with the prospective participant's resources?	▪ Diversity or complementarity of resources adds value across the network. ▪ Whether a participant is a net seller or buyer will be part of the calculation of benefits from market participation. ▪ Benefits of the market are proportional to imperfections in the market and the nature of a participant's resources—e.g., can available, rampable, flexible resources derive additional value from participation?
Market Structure and Rules	▪ How do the market's structure and rules impact the economics of a participant's assets and operating profile?	▪ Equity toward all participants is a key consideration. Specifically, would one state or region benefit versus another?
Ease of Exit	▪ What are the barriers to exit?	▪ Before joining the market, it may be necessary to determine "no regrets" actions to allow for exit in the future if circumstances change (e.g., market dynamics are not as expected, changes in alternative markets making them more attractive, etc.).

Key Questions as Western Imbalance Markets Continue to Evolve

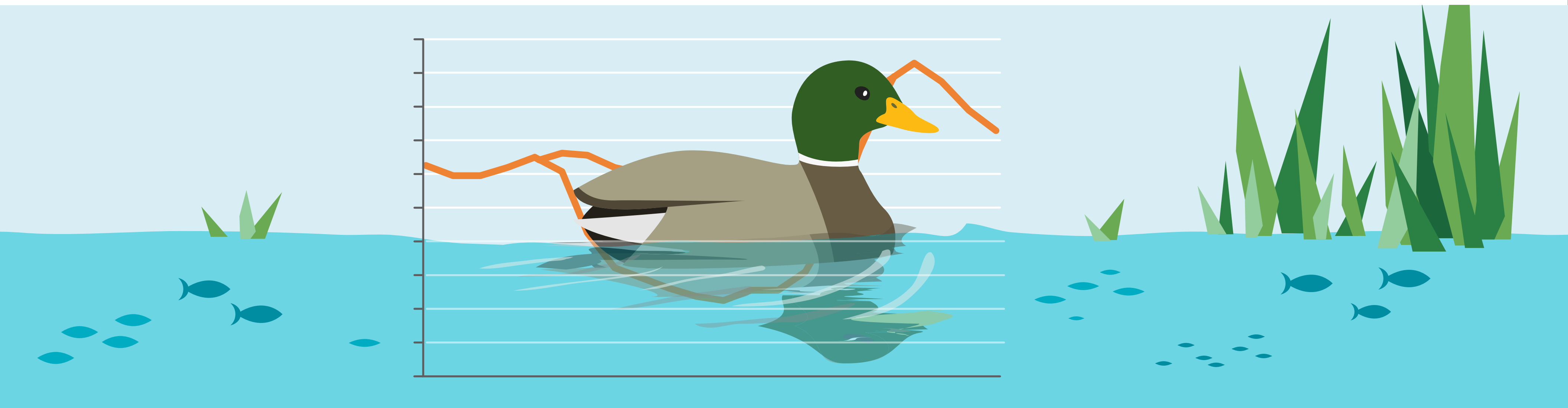
- The imbalance markets may not be a panacea for the sale of excess renewable energy, especially in high-resource, lower-demand periods. Even with the Western EIM, in the first five months of 2019, California curtailed 37% more available renewable energy—nearly 631 GWh—than in all of 2018. Thus, breadth and expanded participation in the market will be critical.
- While some interdependence exists between the Eastern and Western Interconnection at SPP's border, it is unclear whether that seam will pose any hurdle to further expansion of WEIS.
- The imbalance markets may represent a toehold for other markets or roles for CAISO and SPP, respectively. Each has left open the door for expansion into both day-ahead markets, where larger dollar and energy volumes are transacted, and reliability coordination services (emergency operations management and system restoration).
- Observers see some of this activity as a precursor to a western RTO, although disparate interests, resources, population densities, and policies—as well as historic independent mindedness—constitute hurdles to such a development. Because of resistance to loss of state control, for example, California's legislature has twice rejected the possibility of a western RTO.

IMPLICATIONS

For potential participants in the western market, this evolution of energy markets presents new opportunities—especially for supply cost optimization, renewables generation integration, and transmission planning and use. Entities in the West already in or considering joining EIMs will see an increased focus on building organizational capabilities for managing market participation—along with state and federal regulatory relationships—to optimize benefits.

Notes: *Savings are based upon a counterfactual analysis of what imbalance energy would have cost but for dispatch via the Western EIM.

Sources: S&P Global Market Intelligence; CAISO, "Energy Imbalance Market Overview: Presentation to Portland General Electric EIM OATT Stakeholder Meeting" (Oct. 14, 2016); CAISO Dept. of Market Monitoring, 2018 Annual Report on Market Issues and Performance (May 2019); CAISO, Western EIM Benefits Report, Second Quarter 2019 (July 31, 2019); Western Area Power Administration, "Energy Imbalance Markets in the West" (July 15, 2019); SPP, A Proposal for the Southwest Power Pool Western Energy Imbalance Service Market (WEIS) (April 2019); Public Service Company of Colorado, FERC Docket No. ER16-178-000, Order Accepting Joint Dispatch Agreement and Tariff Revisions, 154 FERC ¶61,107 (Feb. 18, 2016).



CALIFORNIA "DUCK CURVE" REVISITED
GROWING FAT IN THE CALIFORNIA SUN

Despite California's pursuit of a wide range of mitigation strategies, the duck curve easily surpasses original expectations.

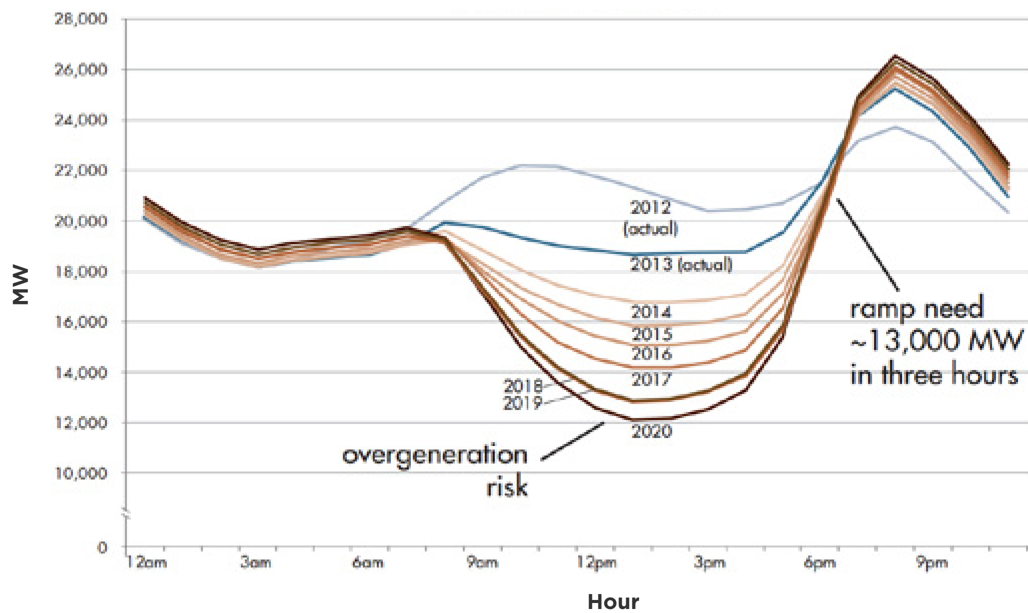
The Duck Arrives Sooner and Larger than Expected

- In 2013, CAISO conducted an analysis to understand the impact of increasing penetrations of renewable resources. This resulted in the iconic duck curve chart, which projected changes in springtime net load through 2020 (see chart at top right of page 12).
- Net load represents the load served by the electric system, minus the load served by variable generation (i.e., wind, solar PV, and solar thermal). Power providers follow this metric closely because it measures the load that must be served by dispatchable generation.
- Even more important, higher penetrations of solar result in oversupply risks during the middle of the day and steep ramp-ups for dispatchable generation in the evening.
- These conditions can directly impact market prices (e.g., negative prices during oversupply periods) and the use of dispatchable generation (e.g., increased cycling).
- In 2016, ScottMadden looked at CAISO's 2013 projection to ascertain its causes and development and found that the duck curve was real and growing faster than expected, primarily due to utility-scale solar. We recently took a fresh look at California's duck curve to find out how it was evolving.
- Our analysis of CAISO's data indicates the minimum daytime net load in March 2019 was approximately 7,000 MW (see chart at lower right of page 12), roughly 40% lower than the minimum net load originally forecast for March 2020.

KEY TAKEAWAYS

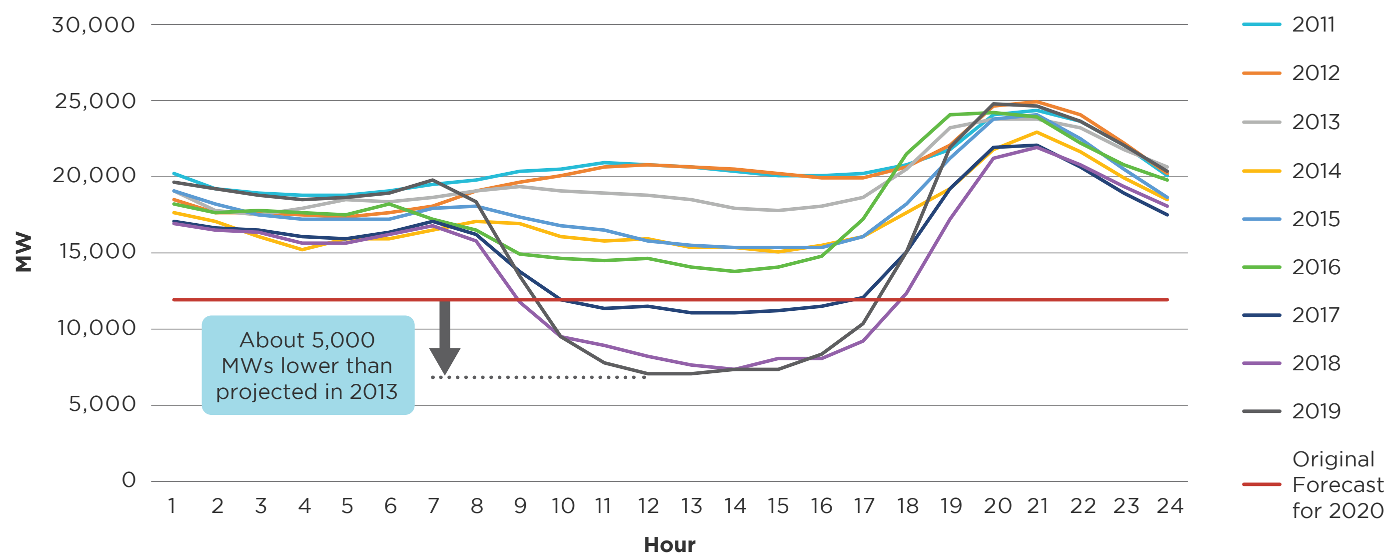
- The California duck curve, introduced by CAISO, illustrates how increasing solar capacity can change net load or the load served by dispatchable generation.
- Driven primarily by utility-scale solar, the deepening duck curve poses operational challenges stemming from the risk of daytime oversupply and steep evening ramps for dispatchable generation.
- Our analysis finds that duck curve impacts not only exceed original forecasts, but they are also pervasive and growing year-round.
- CAISO is pursuing multiple solutions—ranging from an energy imbalance market to storage—but more innovation may be needed.

CAISO Actual and Projected Net Load at March 31 (2012-2020) (as of 2013)



Source: CAISO

Lowest March Daytime Net Load (2011-2019)

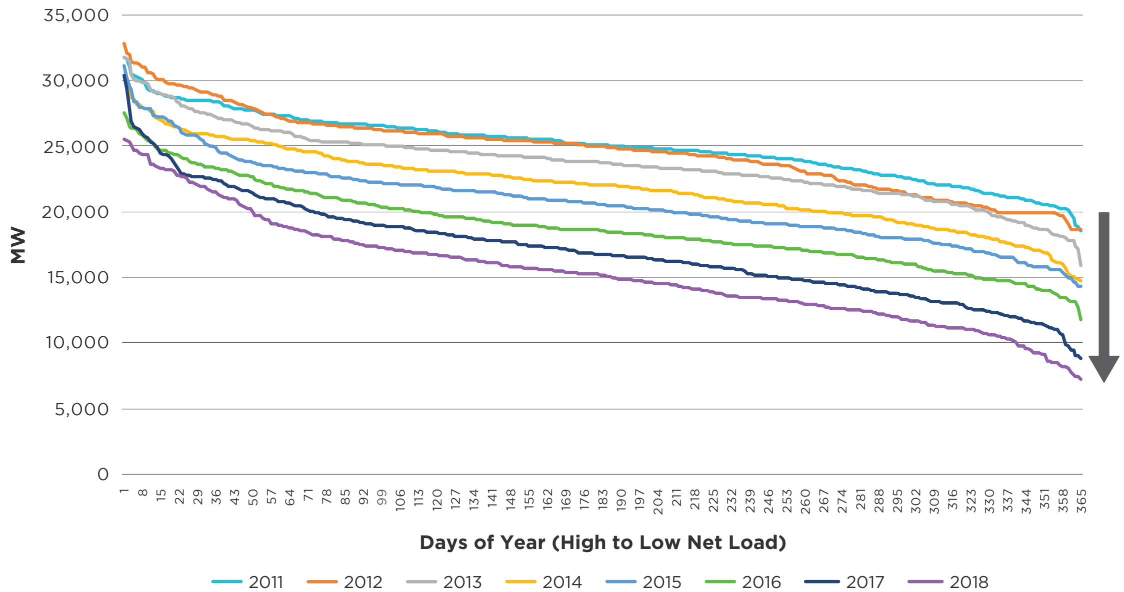


Sources: CAISO; ScottMadden analysis

Duck Curve Impacts Are Pervasive and Expanding Year-Round

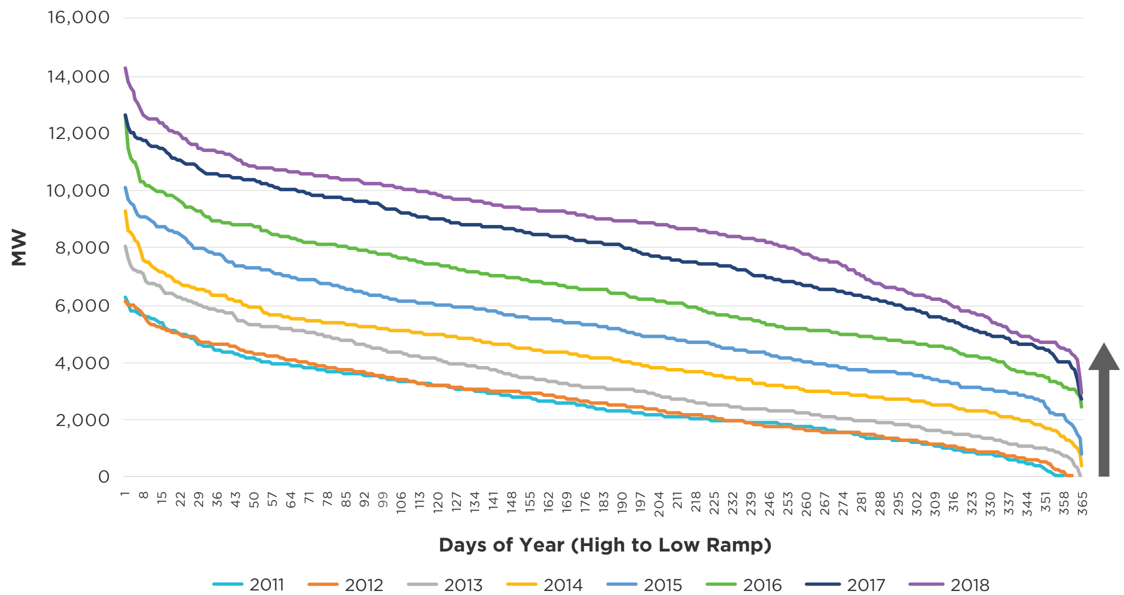
- ScottMadden also analyzed the year-round implications of the duck curve. Our methodology included identifying the minimum daytime net load (i.e., duck belly) and maximum late-day three-hour ramp-up (i.e., duck neck) for each day of the year between 2011 and 2018. Each metric was then ranked by size within each year.
- The results showed the impacts of the duck curve consistently increased every year (see graphs at right).
- Key observations concerning the minimum daytime net load include:
  - **Annual lowest net load over time:** The most extreme daytime net load low (i.e., the lowest point in the year) dropped 61% from 18,531 MW in 2011 to 7,206 MW in 2018.
  - **Persistent low net load throughout the year:** But it was not just the lowest points. More than 80% of the days in 2018 had a minimum net load below the lowest point recorded in 2011.
- Key observations concerning the late-day three-hour ramp-up include:
  - **Growing ramp-up needs:** The most extreme late-day three-hour ramp-up (i.e., the highest point in the year) increased 129% from 6,245 MW in 2011 to 14,304 MW in 2018.
  - **One-third of peak:** The maximum 2018 ramp-up was roughly one-third of system-peak served that year.

CAISO Minimum Daytime Net Load (2011–2018)



Sources: CAISO; ScottMadden analysis

CAISO Late-Day Three-Hour Ramp (2011–2018)



Sources: CAISO; ScottMadden analysis

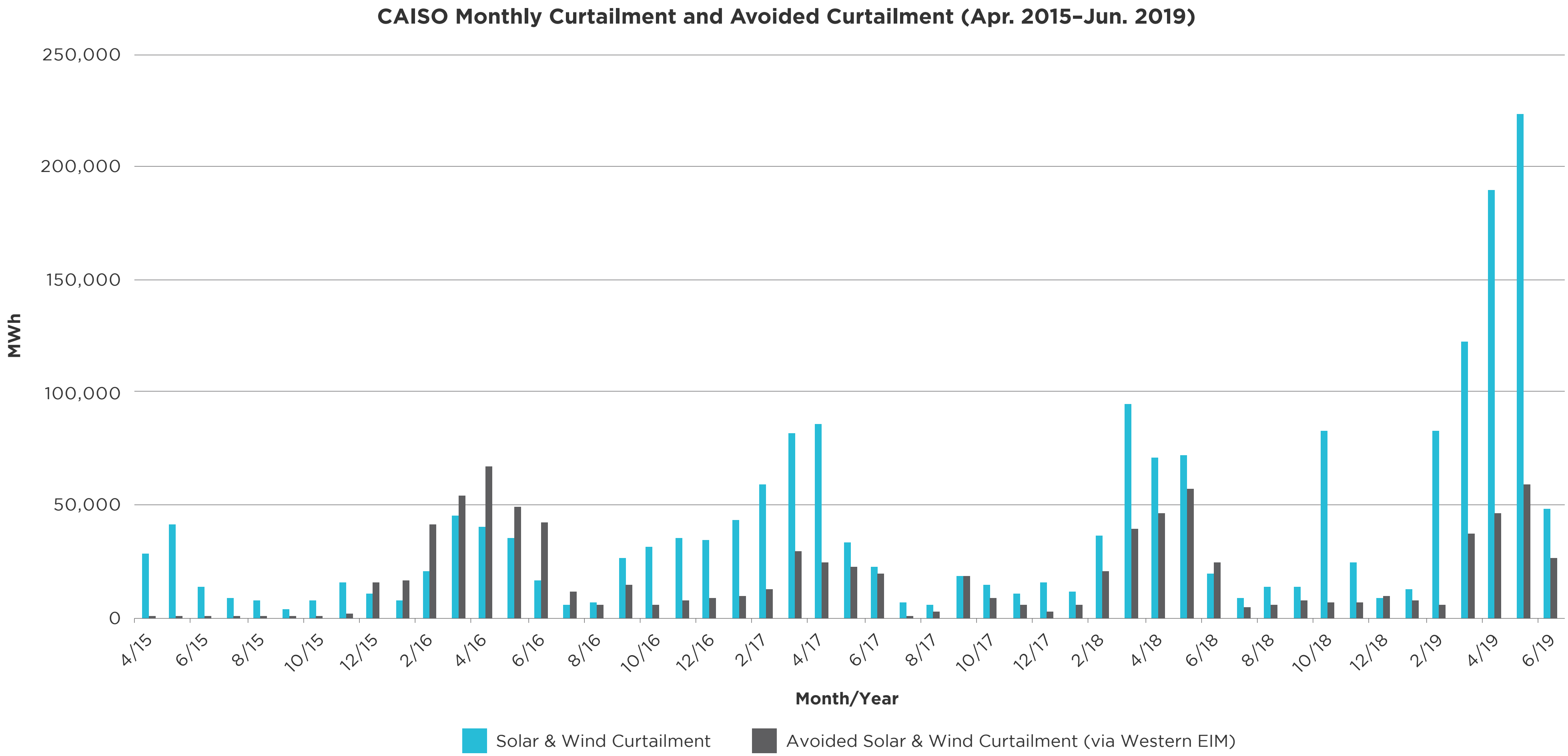
A Broad Set of Solutions and Yet More Innovation May Be Needed

- To manage duck curve impacts, CAISO is pursuing a broad array of approaches and technologies (see table at right).
- Despite ongoing efforts and significant progress in implementing these efforts, CAISO still curtailed record amounts of solar and wind in the first half of 2019.
- Curtailments hit consecutive monthly records in March, April, and May. Through June, curtailments equaled roughly 3% of the solar and wind production used to serve CAISO's load.
  - Most curtailments have been economic, meaning renewable systems submit decremental bids to reduce or quit production.
  - The Western Energy Imbalance Market (Western EIM) serves as an outlet for, among other things, excess solar energy from California. However, excess renewable energy has proven too much for the larger market to absorb, as the amount of curtailment avoided through the Western EIM has not increased significantly compared to 2018 (see chart on next page).
- Significant growth in the number of hybrid systems, which pair renewables and storage, may begin to ease duck curve impacts.
  - In August 2018, hybrid projects comprised nearly 50% of the 74,490 MW in CAISO's interconnection queue.
  - More than 31,350 MW of the queue originate from solar plus storage projects, while roughly 5,320 MW come from wind plus storage projects.
- David Olsen, chair of CAISO's governing board, has also stressed the need to rethink traditional renewable energy PPAs. In comments echoing Hawaii's Renewable Dispatchable Generation PPA (see page 33), Mr. Olsen noted in a recent interview, "If we paid clean resources to provide power services instead of just energy, we wouldn't have to curtail renewables as much, because we would use them not [only] to provide energy, but [also] to supply the grid capabilities that gas now provides."

Duck Curve Mitigation Efforts

Approach or Technology	Action
Storage	Increase the effective participation of energy storage resources
Demand Response (DR)	Enhance DR initiatives to enable up and down adjustments in consumer demand when warranted by grid conditions
Time-of-Use (TOU) Rates	Implement TOU rates that match consumption with efficient use of clean energy supplies
Minimum Generation	Explore operational opportunities to reduce minimum-operating levels for existing generators, thus making room for increased renewable production
Western EIM Expansion	Expand the Western EIM to include new participants
Regional Coordination	Offer a more diversified set of clean energy resources through a reliable, cost-effective regional market
Electric Vehicles (EV)	Incorporate EV-charging systems responsive to changing grid conditions
Flexible Resources	Invest in modern, fast-responding resources that can follow sudden increases and decreases in demand

Source: CAISO



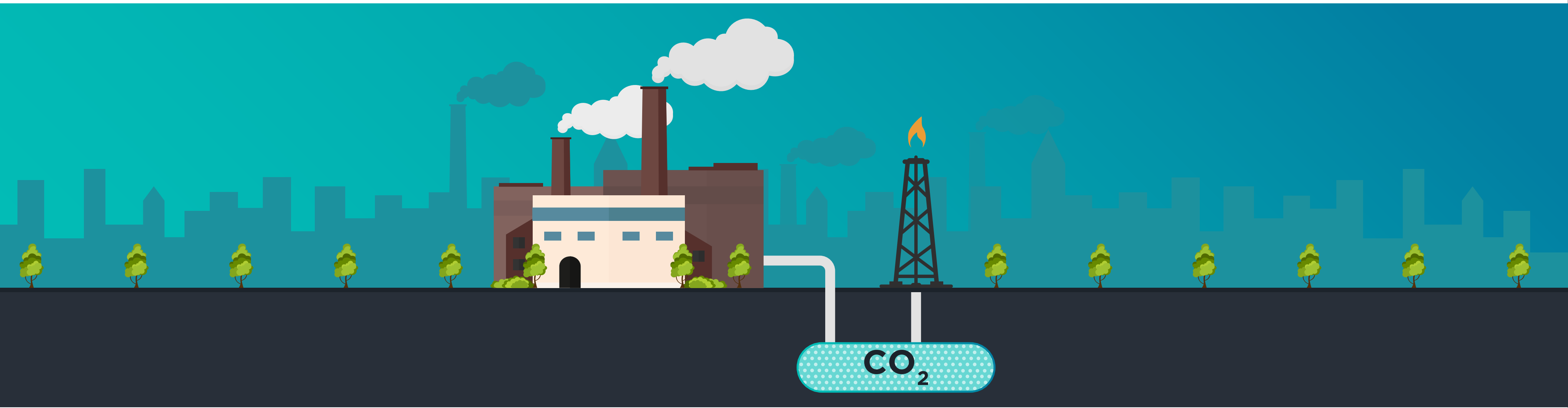
Source: CAISO

IMPLICATIONS

The California duck curve features prominently in industry discussions about a renewables abundant future grid. In keeping with CAISO's predictions, the duck curve has consistently grown each year. As a result, CAISO is managing growing daytime oversupply risks and steeper evening ramps for dispatchable generation. Pairing renewables with storage may help slow future duck curve impacts. In addition, new paradigms, such as innovative PPAs, may be required to tame the duck.

Notes: Data for the analysis was collected from CAISO's Daily Renewables' hourly averages report. We define daytime minimum net load as the lowest hourly net load between 8:00 AM and 8:00 PM. We define the late-day three-hour ramp as the steepest three-hour ramp between 2:00 PM and 9:00 PM.

Sources: CAISO; S&P Global Market Intelligence; Greentech Media; ScottMadden analysis; C. Vlahoplus, P. Quinlan, and G. Litra, "Revisiting the Duck Curve: An Exploration of Its Existence, Impact, and Migration Potential" (Oct. 2016), available at https://www.scottmadden.com/insight/revisiting-duck-curve-exploration-existence-impact-migration-potential/.



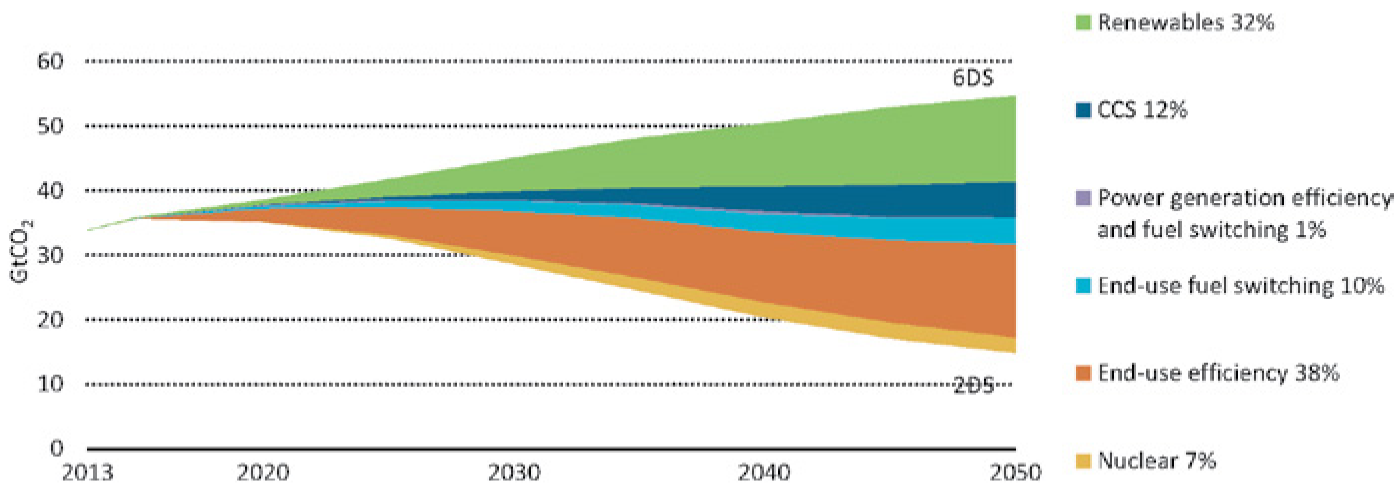
CARBON CAPTURE, UTILIZATION, AND STORAGE
NEW LIFE FOR A FAMILIAR TECHNOLOGY?

Increasing concern about falling short of Paris goals leads global energy policymakers to reconsider carbon capture.

CCUS as Key to Net Zero Ambitions

- Interest in carbon capture, utilization, and storage (CCUS) is being rekindled globally as decarbonization remains a priority for many in both the public and private sectors. This interest builds upon ongoing attention to CCUS as a greenhouse gas reduction tool, acknowledged by the U.N. Intergovernmental Panel on Climate Change (IPCC).
- The IEA recently highlighted a need to accelerate CCUS deployment in its Sustainable Development Scenario (SDS). The SDS envisions emissions reductions in accordance with the Paris Agreement's ambitions to limit global temperature increases to 2°C. IEA's least-cost approach requires 12% of cumulative CO_2 emissions reductions through 2050 come from CCUS (see graph on next page). This would require scaling up global CO_2 emissions reductions from annual CCUS from about 28 Mtpy today to 6.1 gigatons by 2050. In this scenario, about 55% of CO_2 captured is from the power sector, with the remainder from industry and fuel transformation (production and processing).
- Further, in June 2019, the United Kingdom became the first major economy to declare its intention of achieving net zero CO_2 emissions by 2050. Observers note that CCUS will be needed to get to net zero emissions, as some industrial sectors could find decarbonization prohibitively expensive. Offsetting emissions with, for example, bioenergy with carbon capture and storage (BECCS) is seen as a viable approach to economically netting some residual emissions.
- Finally, in the February 2018 U.S. budget, Congress passed tax credits to incentivize new CCUS projects, with values of \$15 to \$50 per metric ton of CO_2, depending upon the application (see page 19).

CCS Is a Key Measure to Achieve IEA's 2°C Scenario*



*See note at end of section.
Source: IEA

A Recent History and a New Catalyst

- CCUS has been around for decades; however, significant interest in CO_2 emissions reduction was sparked in the mid- to late 2000s by the Copenhagen COP15 climate negotiations and the IPCC's special report on CCUS, as well as technical progress and interest in preserving fossil generation for fuel diversity. By 2010, global commitments to CCUS projects totaled $30 billion.
- Progress has been halting, however, as impacts of a global economic slowdown and other early challenges have impeded progress. Only $12.3 billion was invested in CCUS from 2005 to 2016, and only one in three projects proceeded to a final investment decision during that period.
- CCUS technology has proven expensive for power generation application, with high-parasitic load for the capture process (see page 20). And the most noteworthy U.S. power generation application—the multi-billion-dollar Kemper County Integrated Gasification Combined Cycle—succumbed to technical problems with gasification and related capture, as well as the shift to significantly lower natural gas prices.
- The reality of continued fossil fuel use, however, has led to re-emphasis on CCUS as a CO_2 reduction strategy. For example, about 200 GWs of coal-fired generation is currently in construction around the world and unlikely to be closed in the near term. Also, some industrial processes, such as iron, steel, chemical, and cement production, are especially difficult or expensive to abate because of the high temperatures required or where carbon is inherently involved in production.
- CCUS deployment is lagging in the United States behind what is required under the 2°C target of the Paris Agreement. Only some 31 Mtpy are currently captured and sequestered in the United States, while Paris targets require 200 to 1,000 Mtpy by 2030.

KEY TAKEAWAYS

- **CCUS is drawing interest as industry and policy leaders seek Paris target CO_2 emissions reductions, but challenges are seen in the decarbonization of certain processes.**
- **In the United States, policy enablers, such as CCUS tax credits, are encouraging technology development in CCUS.**
- **The beneficial use of CO_2, including enhanced oil recovery, is seen as a potential added value for CCUS.**
- **However, technology improvements are needed to drive down CCUS costs, and new technologies, such as the supercritical CO_2 Allam cycle, are being tested.**

Section 45Q Updated	
Increases value of credit and pegs it to inflation after 2026	▪ 10-year ramp-up from \$10 to \$35 per ton for CO_2 stored geologically through EOR ▪ 10-year ramp-up from \$10 to \$35 per ton for other beneficial uses, such as converting carbon emissions into fuels, chemicals, or such useful products as cement ▪ 10-year ramp-up from \$20 to \$50 per ton (higher because of lack of economic value vs. uses above) for CO_2 stored in other geologic formations and not used in EOR or for other purposes ▪ Post-2026, the credit will be adjusted to increase with inflation
Lifts cap on credits and clarifies eligibility	▪ No cap on 45Q credits ▪ Projects beginning construction before 2024 can claim credit for up to 12 years after placed in service ▪ Performance-based, depending upon CO_2 stored
Expands industries eligible and lowers threshold for industrial and non-EOR beneficial use	▪ Annual carbon capture thresholds for credit eligibility (differs by industry and use): – 25,000 to 500,000 metric tons: beneficial use projects other than EOR – At least 100,000 metric tons: all other industrial facilities, including direct air capture (other than electric-generating units) – At least 500,000 metric tons: electric-generating units ▪ Expands to include other carbon oxides, including carbon monoxide
Increases flexibility for entity's use of the credit	▪ Equipment owner receives tax credit and can allow another entity involved in storing or using the carbon to claim the credit

Sources: Great Plains Institute; Hunton Andrews Kurth; FUTURE Act

Back to the FUTURE: Congress Expands Incentives for CCUS

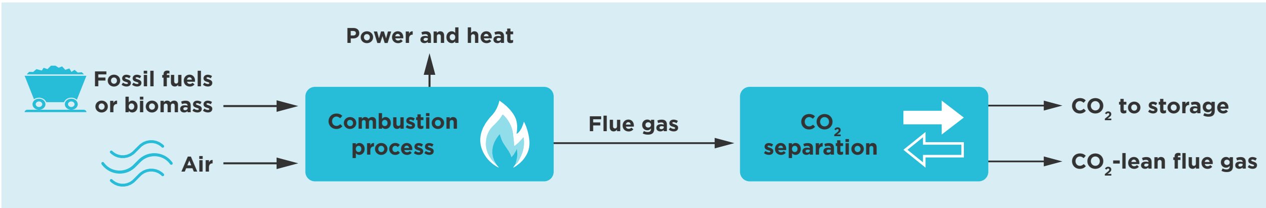
- Section 45Q of the U.S. federal tax code provides tax credits for CO_2 capture and storage for enhanced oil recovery (EOR), gas recovery, or permanent storage. Like the production tax credit, the 45Q CCUS credit is tied to performance (i.e., verified, permanently sequestered carbon oxides).
- A bipartisan bill, the Furthering Carbon Capture, Utilization, Technology, Underground Storage, and Reduced Emissions Act (FUTURE Act), was introduced in 2017 to expand the dollar amount of the credit, lifting the CO_2 cap for the program, expanding applications, and lowering eligibility thresholds for projects. The FUTURE Act was enacted as part of a February 2018 federal budget deal.
- An updated Section 45Q now expands the credit as shown in the table to the left.
- Proponents of the expanded tax credits hope they will spur lower capture cost opportunities, particularly for industrial sources with concentrated CO_2 waste streams.

The Technologies: What Is CCUS?

- Carbon capture technology is comprised of three types: pre-combustion, post-combustion, and oxy-fuel combustion. Oxy-fuel technology has improved over the past decade, but no projects are currently planned to test this technology at scale. A summary comparison of these technologies is shown on page 20.
- Amine solvent-based post-combustion capture is most suitable for retrofits, but it causes a 32% to 65% increase in energy costs.

Comparison of CO_2 Capture Technologies

POST-COMBUSTION



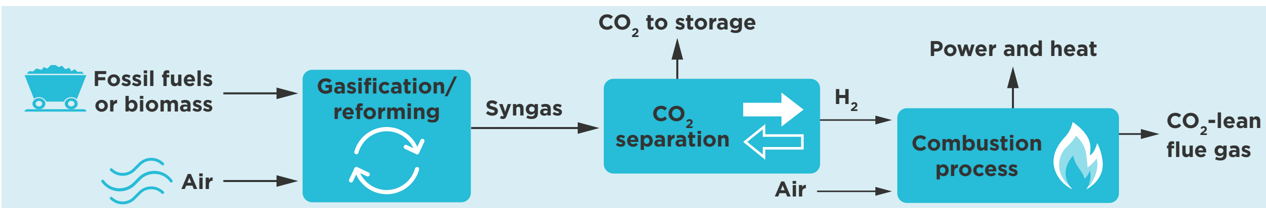
Coal-Fired Costs*	Gas-Fired Costs*
Capital ($/kW): $1,980	**Capital ($/kW):** $870
Avoided CO_2 ($/ton): $34	**Avoided CO_2 ($/ton):** $58

Application Areas
- Coal-fired and gas-fired plants

Advantages
- Technology more mature than other alternatives
- Can easily retrofit into existing plants

Disadvantages
- Low CO_2 concentration affects capture efficiency

PRE-COMBUSTION



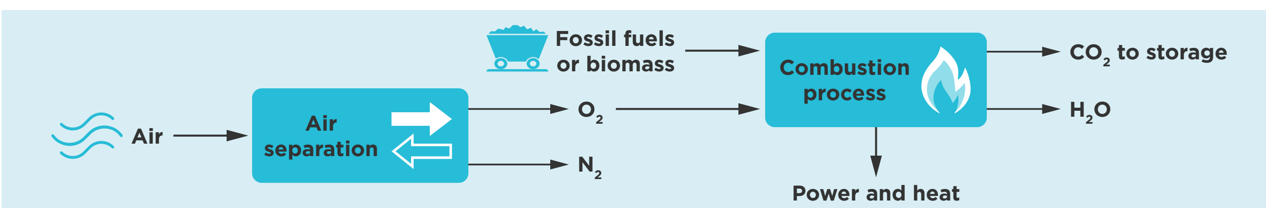
Coal-Fired Costs*	Gas-Fired Costs*
Capital ($/kW): $1,820	**Capital ($/kW):** $1,180
Avoided CO_2 ($/ton): $23	**Avoided CO_2 ($/ton):** $112

Application Area
- Coal-gasification plants

Advantages
- High CO_2 concentration enhances sorption efficiency
- Fully developed technology, commercially deployed at the required scale in some industrial sectors
- Opportunity for retrofit to existing plant

Disadvantages
- Temperature associated heat-transfer problem and efficiency decay issues associated with the use of hydrogen-rich gas turbine fuel
- High-parasitic power requirement for sorbent regeneration
- Inadequate experience due to few gasification plants currently operated in the market
- High-capital and operating costs for current sorption systems

OXY-FUEL COMBUSTION



Coal-Fired Costs*	Gas-Fired Costs*
Capital ($/kW): $2,210	**Capital ($/kW):** $1,530
Avoided CO_2 ($/ton): $36	**Avoided CO_2 ($/ton):** $102

Application Areas
- Coal-fired and gas-fired plants

Advantages
- Very high CO_2 concentration that enhances sorption efficiency
- Mature air separation technologies available
- Reduced volume of gas to be treated, hence smaller boiler and other equipment required

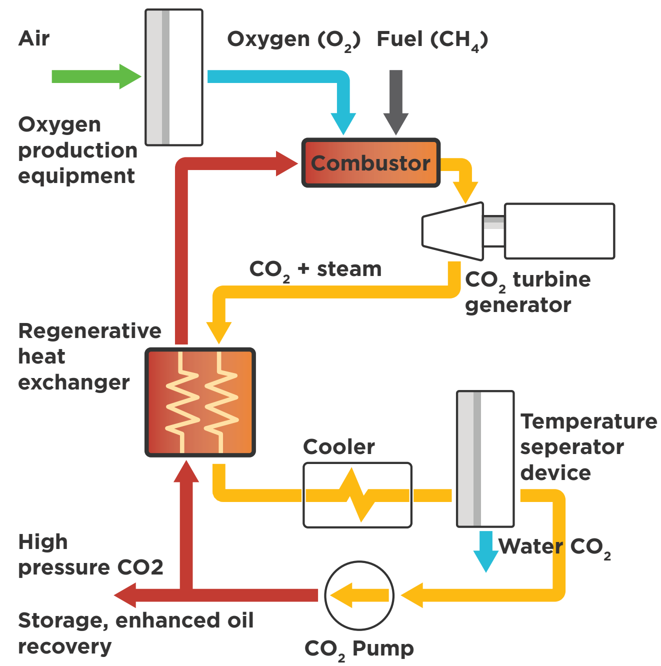
Disadvantages
- High-efficiency drop and energy penalty
- Cryogenic O_2 production is costly
- Corrosion problems may arise

Note: *Cost estimates from 2006 IEA report, cited in 2014 Leung paper. Estimates exclude storage and transportation costs.
Sources: IEA; *Renewable and Sustainability Energy Reviews*

Something Old, Something New

- EOR has been a CCUS development driver in the United States, reducing extraction costs. Five of six large-scale U.S. CCUS facilities, commencing operations since 2009, have used EOR as a storage mechanism. There is some concern that using CO_2 for EOR undoes the carbon reduction (because of hydrocarbon extraction and use). However, some consideration is being given to "EOR+," which could store more CO_2 than created from extracted oil, but it requires more rigorous sequestration and verification standards.
- Proponents of net zero emissions are also studying potential BECCS, which could serve as a negative emissions "sink" that could offset other net positive emitting sectors. However, a sustainable biomass supply and a CO_2 transportation network are key to getting BECCS to scale.
- Technology development continues, with one firm testing the new Allam cycle by building a 50 MWt demonstration plant, with the potential to build a larger 300 MW combined-cycle plant in 2020 (see below).
- Finally, in Europe and Australia, some hydrogen production initiatives, enabled by CCUS, are in the planning stage. And more carbon-to-value (C2V) products are being produced using CO_2 as fertilizer feedstock, as well as foams for mattresses, furniture, bricks, and cement.

Overview of Allam Cycle Supercritical CO_2 Thermal Power Plant System



Source: Toshiba Corp.

And Now for Something New: Will the Allam Cycle Be a CCUS Breakthrough?

- A priority for CCUS technology development is the improvement of efficiency—the reduction of energy use for the carbon capture process (parasitic load) that lowers output of useful energy.
- NET Power, a small company with financial backers 8 Rivers Capital, Exelon Corp., McDermott, and Oxy Low Carbon Ventures (a subsidiary of Occidental Petroleum Corp.), has constructed a demonstration plant in La Porte, Texas, (near Houston) testing the Allam cycle for emissions-free power generation in a natural gas-fired power plant. Its goal is to produce emissions-free power at comparable cost to a gas-fired combined-cycle power plant.
- The La Porte plant is a $140 million, 25 MWe (50 MW thermal), direct-fired supercritical oxy-combustion natural gas-fired plant. The unique feature of the Allam cycle is its use of supercritical CO_2 (sCO_2), heated to about 720°C, as the fluid gas for driving the generator's turbine blades (see graphic above right). The NET Power plant burns a mixture of natural gas and pure oxygen combined with CO_2 to produce a working fluid gas, which is a mix of mainly CO_2 and H_2O that is used to drive the turbine generator. This gas is then cooled through a heat exchanger, and water is separated out to create a nearly pure CO_2 stream. The stream is pressurized, and a major part of this flow is fed back to the combustor to begin the cycle anew. The remaining part of the CO_2 flow can easily be collected and put into a pipeline for storage, sequestration, or enhanced oil recovery.
- The La Porte facility successfully tested the combustor in the summer of 2018, and it is expected to be completed in late 2019. If the La Porte facility meets expectations, NET Power plans to use its learnings to support development of 300 MWe commercial scale plants. The key will be to drive down first-of-a-kind construction costs and generate power at a cost equivalent to a combined-cycle plant without carbon capture. Other supportive policies, such as the aforementioned 45Q tax credit, beneficial use of residual CO_2, and a potential cost of carbon, could aid this technology.

IMPLICATIONS

After some dormancy, CCUS is being reconsidered for power and industrial applications. As complete decarbonization appears prohibitively expensive, some energy industry leaders—with U.S. incentives—are placing measured bets on CCUS technology development to enable both carbon reduction and energy security through fuel diversity.

Note: *6DS is IEA's "business as usual" energy pathway scenario, which it projects will yield 6°C increase in global average temperature. 2DS is an energy pathway scenario expected to limit temperature increases to 2°C.

Sources: BP Energy Outlook: 2019 Edition (June 2019); R. Edwards and M. Celia, "Infrastructure to enable deployment of carbon capture, utilization, and storage in the United States," in Proceedings of the National Academy of Sciences (Sept. 2018), 115 (38) E8815-E8824; DOI: 10.1073/pnas.1806504115, at www.pnas.org/content/115/38/E8815; D. Leung, G. Caramanna & M. Maroto-Valer, "An overview of current status of carbon dioxide capture and storage technologies," *Renewable and Sustainable Energy Reviews*; FUTURE Act, S.1535 – 115th Congress (2017-2018), available at https://www.congress.gov/bill/115th-congress/senate-bill/1535; Great Plains Institute, "The FUTURE Act: A Side-by-Side Comparison of Changes to the 45Q Tax Credit for Carbon Capture and Storage" (Mar. 2018); Great Plains Institute, "Before & After: How the FUTURE Act Reformed the 45Q Carbon Capture and Storage Tax Credit" (Mar. 5, 2018), available at https://www.betterenergy.org/blog/future-act-reformed-45q-carbon-capture-storage-tax-credit/; Hunton Andrews Kurth, Section 45Q Tax Credit Enhancements Could Boost CCS (Feb. 22, 2018), available at https://www.huntonnickelreportblog.com/2018/02/section-45q-tax-credit-enhancements-could-boost-ccs/; IEA, "U.S. budget bill may help carbon capture get back on track" (Mar. 12, 2018); NET Power; McDermott; Toshiba; "NET Power Developing Multiple Zero-Carbon Natural-Gas Plants, Exec Says, At Lower Cost Than Conventional Plants," Forbes.com (July 22, 2019); "Potential Carbon Capture Game Changer Nears Completion," *MIT Technology Review* (Aug. 30, 2017); "Zero Emissions Power Cycle Achieves First Fire," *Modern Power Systems* (June 8, 2018); "Inside NET Power: Gas Power Goes Supercritical," *Power* (Apr. 1, 2019); Bloomberg New Energy Finance & Business Council for Sustainable Energy, 2019 Sustainable Energy in America Factbook (Feb. 2019).

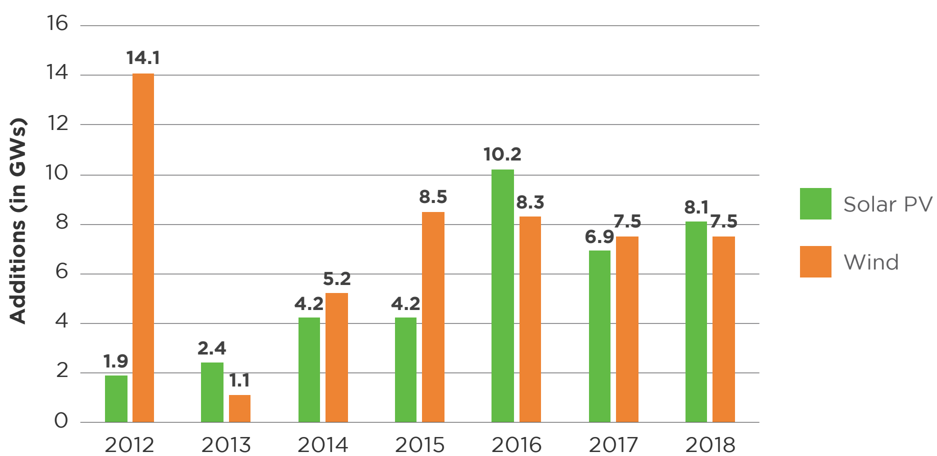
UTILITY SCALE OR DISTRIBUTED?
SHAPING A PATH TOWARD HIGH-RENEWABLE PENETRATION

The case for utility-scale renewables in a high-renewable penetration future.

Envisioning the Electric Grid with High-Renewable Penetrations

- In recent years, the growth of renewables has included a proliferation of utility-scale wind and solar and distributed solar.
- This has brought changes in economic and operational aspects of the grid from planning through energy delivery.
- While some common benefits and challenges to integrating renewables exist, not all renewables are created equal.
- As the United States pushes toward higher penetrations of renewables, utility strategies will need to consider the important differences between utility-scale and distributed renewables.
- Even more importantly, they will need to consider how best to integrate and effectively manage these resources to maximize benefit to customers and the grid.

U.S. Annual Utility-Scale Solar and Wind Additions (2012-2018) (in GWs)



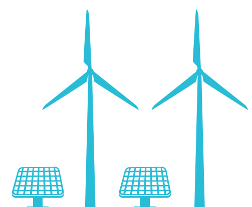
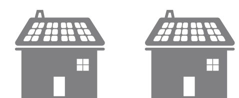
Source: Bloomberg New Energy Finance

KEY TAKEAWAYS

- **When compared to distributed resources, utility-scale resources are more cost effective because of economies of scale and are administratively easier to manage.**
- **Market options to integrate utility-scale resources are also more robust, mature, and easier to understand than market options for distributed resources (i.e., aggregation).**
- **Meanwhile, a growing number of states and utilities are looking beyond renewable portfolio standards and establishing 100% clean energy commitments.**
- **The integration strategies pursued by electric utilities and grid operators will vary depending on the current state of renewables penetration.**

Similar but Different: Advantages of Utility-Scale Renewables

- Important differences exist between utility-scale and distributed renewables.*
- A comparison shows that utility-scale renewables have three notable advantages over distributed renewables:
  - **Cost:** Utility-scale renewables benefit from economies of scale. In Q1 2019, the average installation cost of residential solar was three times more expensive than fixed tilt utility-scale solar (in $ per Watt).
  - **Speed to Scale:** With many states increasing their renewable energy targets, the reduced administrative overhead (e.g., applications, interconnection studies, engineering, etc.) of a single utility-scale installation versus an equivalent multitude of distributed systems leads to faster achievement of robust renewable policy goals.
  - **Grid Integration:** Distributed renewables can introduce greater operational complexity due to limited visibility and control across what could be thousands of systems.

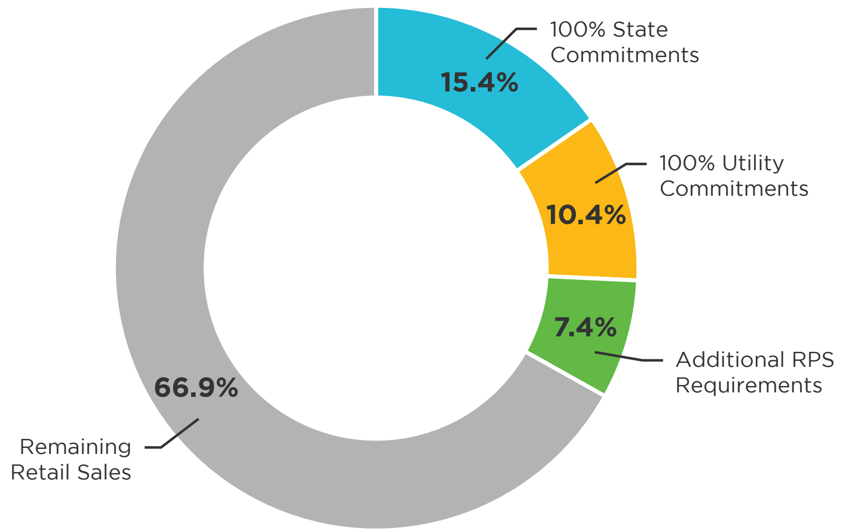
	Utility-Scale Renewables	Distributed Renewables
Definition	Large (typically > 1 MW) generating systems using renewable technologies	Smaller (typically < 1 MW) generating systems using renewable technologies
Attributes	▪ Designed and operated to deliver the maximum amount of electricity in real time ▪ May be connected to the distribution network or bulk electric system ▪ Potential to be controllable by leveraging smart inverters and operating intelligence to provide targeted curtailment, more predictable output, or other grid reliability services, such as frequency regulation ▪ Overwhelmingly compensated through PPAs and, in rare instances, as merchant plants lacking PPAs in wholesale markets	▪ May be designed to offset load or provide two-way power flow back to the grid ▪ May be connected in front of the meter to the distribution network or behind the meter on customer premises ▪ May be aggregated for operator control but generally are not individually dispatchable or controllable by grid operators ▪ May be compensated through net-metering tariffs or providing value by reducing consumption costs

Source: ScottMadden analysis

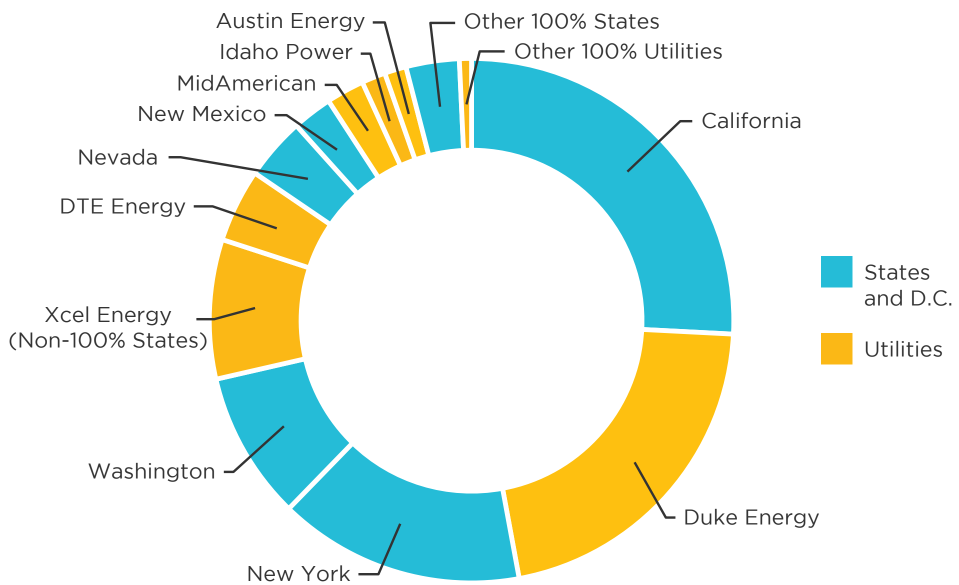
The New Kid on the Block: 100% Clean Energy Commitments

- A growing number of stakeholders are looking beyond traditional renewable portfolio standards and establishing 100% clean energy commitments.
- These commitments will be a major driver that push grid operators to higher renewables penetration in the future.
- "Clean energy" commitments often go beyond renewable resources and include carbon-free generation (e.g., nuclear) or allow for carbon capture.
- Seven states, the District of Columbia, and multiple electric utilities have committed to 100% clean energy goals by 2050 or sooner (see chart at upper right).
- Utilities are also announcing 100% commitments with the most significant being Duke Energy (see chart at lower right).
  - In September 2019, Duke Energy updated its climate strategy with a goal to reduce carbon by at least 50% (compared to 2005) by 2030 and achieve net-zero carbon emissions by 2050. Duke Energy accounted for more than 5% of U.S. retail electricity sales in 2018.
  - Duke Energy notes the path forward will require doubling its renewable portfolio, deploying natural gas to transition from coal, and continuing nuclear plant operations. While existing technologies can provide "significant reductions," the company also stresses new technologies will be needed to meet the 2050 goal.
- And utility commitments continue to proliferate. Xcel Energy, DTE Energy, and others have all announced 100% commitments in recent months.

100% Clean Energy Commitments and RPS Requirements (as Percentage of 2018 Retail Electricity Sales)



Comparison of 100% Clean Energy Commitments by State and Utility (Based on 2018 Retail Electricity Sales)

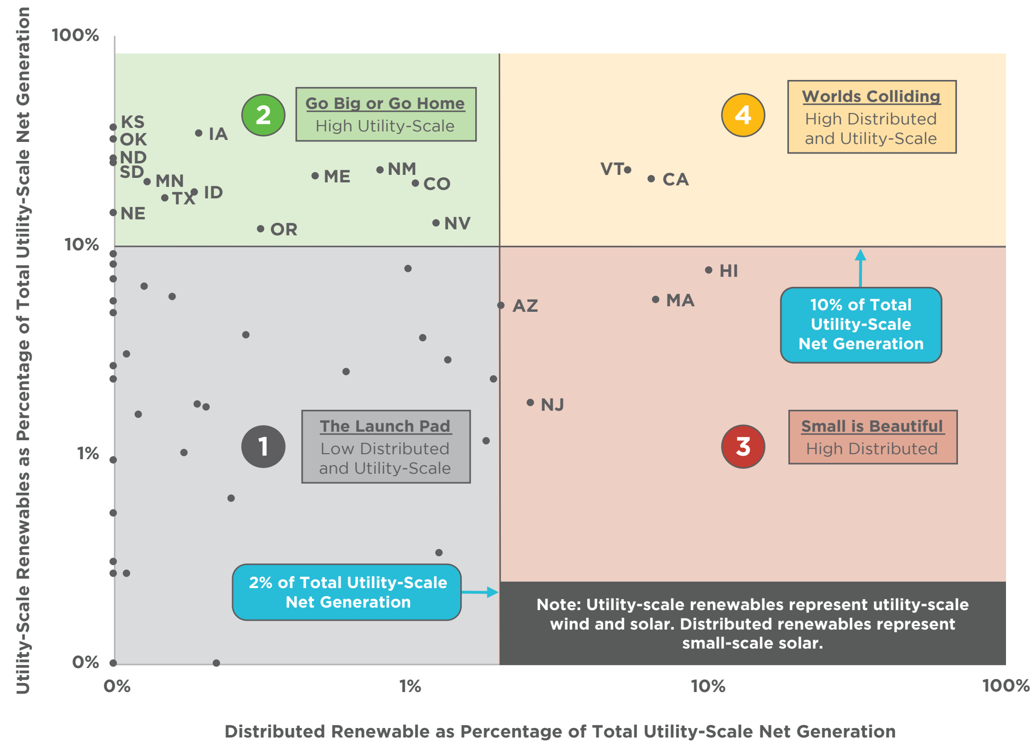


Note: Only the state commitment is counted if both the state and an electric utility have 100% clean energy commitments.
Sources: EIA; industry news; ScottMadden research

The Future Is Now: High Penetrations of Variable Renewables

- Understanding the current penetration of variable, renewable energy generation can provide valuable insights for the future.
- ScottMadden analyzed EIA data to evaluate states currently operating with high penetrations of renewable energy.
  - Utility-scale renewables are limited to solar and wind.
  - Distributed renewables are limited to distributed solar.
- For the purpose of the analysis, we designate a state as having high renewables penetration if it meets one of the following criteria:
  - Utility-scale renewable energy equals at least 10% of total utility-scale generation.
  - Distributed renewable energy equals at least 2% of total utility-scale generation.
- The results are divided into four quadrants (based on logarithmic scales) illustrating the current penetration of variable utility-scale and distributed renewable generation in each state. Key observations for each quadrant include:
  - **The Launch Pad (Quadrant #1):** The majority of states fall into this quadrant, and many may be able to draw lessons from states in the other quadrants.
  - **Go Big or Go Home (Quadrant #2):** One-quarter of states reside in this quadrant. Wind energy is the primary driver, with the exception of solar in Nevada.
  - **Small Is Beautiful (Quadrant #3):** Extremely high electricity prices in Hawaii drove massive investment in distributed solar. Key drivers in the remaining three states include favorable policy support, coupled with either high retail electricity prices or an excellent solar resource.
  - **Worlds Colliding (Quadrant #4):** Though the first is a very small state and the second a very large, highly policy-driven one, Vermont and California are the only states that occupy this quadrant, signaling high penetrations of utility-scale and distributed renewable generation.

Percentage of Variable Utility-Scale Renewable Generation vs. Percentage of Variable Distributed Renewable Generation by State (2018)



Sources: EIA; ScottMadden analysis

Strategies for Integrating High-Renewable Penetrations

- Integration strategies pursued by electric utilities and grid operators will vary depending on their current state.
- Those in a low-penetration environment have the ability to shape the future, while those in a high-penetration environment must leverage existing assets.
- The following strategies may be pursued by stakeholders in each scenario as they prepare for continued growth and higher penetrations of renewable energy.

Scenario (Relevant Quadrants)	Keys to Success	Key Strategies
Low Penetration of Renewables **(Quadrant #1)**	In this position, there is the ability to define a high-renewable energy future state. Advancing utility-scale renewables over distributed renewables would lower costs, scale faster, and reduce operational complexity.	***Establish and Communicate a Vision:*** Establishing a clear vision for what kind and what level of renewables sets a positive, proactive tone to tee up more collaborative and productive work with stakeholders.
High Penetration of Utility-Scale Renewables **(Quadrants #2 and #4)**	Electric utilities will need to address the current renewables penetration and prepare for additional renewables capacity in the future. It will be important to redefine how renewables operate on the grid while meeting customer interests.	***Expand the Role of Renewables:*** Traditional PPAs are structured solely to secure energy. Future additions of utility-scale renewables should require and compensate renewable resources for enhanced grid services (e.g., ancillary services). ***Expand Customer Offerings:*** Despite high penetrations of utility-scale renewables, some customers may still be interested in pursuing distributed resources. It will be critical to provide offerings, such as community solar, that resonate with customer interest while supporting higher penetrations of renewables.
High Penetration of Distributed Renewables **(Quadrants #3 and #4)**	States contending with high penetrations of distributed renewables face significant operational hurdles. In addition to integrating variable resources, the resource may be dispersed across thousands of interconnection points. Supporting customers and making the best use of distributed resources will be key strategies for long-term success.	***Focus on the Customer Experience:*** Improving the customer experience with distributed renewables will be critical. For example, improving interconnection processes and developing refined hosting capacity maps will ensure a quality customer experience. ***Aggregate Distributed Renewables Resources:*** Once installed, the next question is how to best leverage distributed renewables for the benefit of customers and the grid. To ensure maximum value, the aggregation of distributed renewables should consider both energy and ancillary services.

Source: ScottMadden analysis

IMPLICATIONS

The growth of renewables is shaped by many drivers, including state policy, resource availability, technology costs, geography, and customer preferences. As more states transition to high-renewable energy penetrations, utilities will need to be nuanced in their thinking about the best portfolio of products to offer their customers. There are several criteria—including cost, speed to scale, and grid integration—that point toward leveraging utility-scale resources. For a utility that has yet to set a direction, these factors provide a compelling rationale to pursue a strategy comprised predominantly of utility-scale renewables.

Notes:

*For the purpose of this section:

- Utility-scale renewables include wind and solar, as they constitute a significant portion of new capacity additions in recent years.
- Distributed renewables are almost entirely comprised of solar.

See table at page 24 for key attributes for each renewable category.

Sources: EIA; SEPA; Sierra Club; Wood Mackenzie; Bloomberg New Energy Finance/Business Council for Sustainable Energy; ScottMadden analysis.

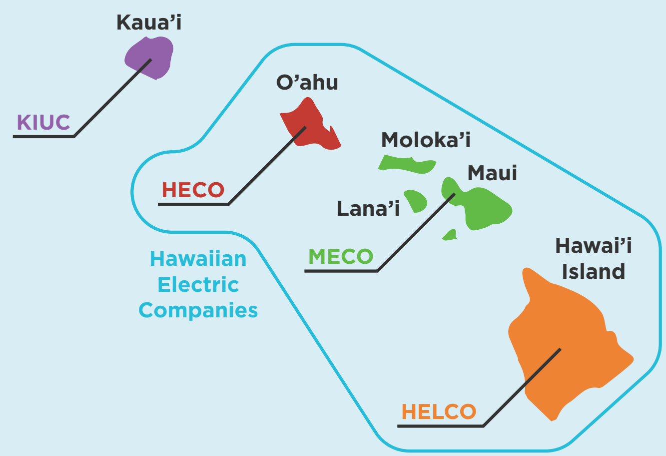
HAWAII TESTBED
BOLD VISION REQUIRES NEW PARADIGMS

Far from the mainland, Hawaii methodically and unassumingly lays the framework to meet a 100% renewable requirement.

Riding the Wave: New Paradigms Outline the Future Ahead

- Best known for high penetrations of distributed rooftop solar, Hawaii has long been called a postcard from the future for a changing utility business. As a result, discrete initiatives undertaken by Hawaiian regulators and utilities, such as performance-based ratemaking, are typically highlighted in the trade press.
- However, a more comprehensive review of Hawaii's electric industry environment reveals regulators and electric utilities diligently paving a path toward a future characterized by high-renewable penetration.
- In fact, a review of Hawaii finds a state embracing new paradigms that change everything from planning, procurement, and operations to utility business models.

Hawaii's Islands and Electric Utilities



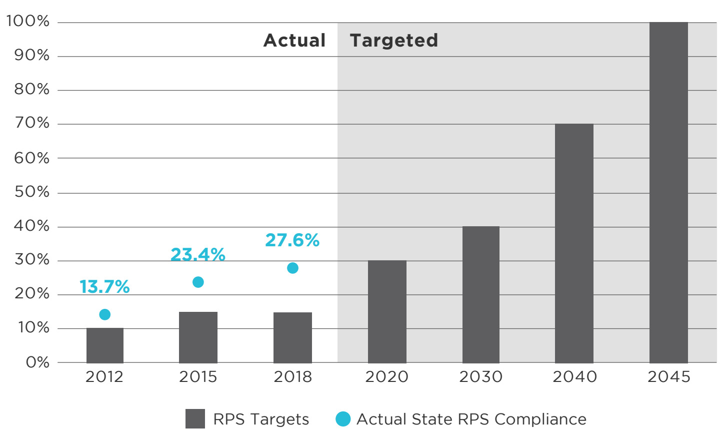
The primary electric utilities servicing the state's power needs are Hawaiian Electric Industries Inc. (HEI) and Kauai Island Utility Cooperative (KIUC). HEI operates three electric utilities, collectively called Hawaiian Electric Companies:

- Hawaiian Electric Company, Inc. (HECO)
- Maui Electric Company, Limited (MECO)
- Hawaii Electric Light Company, Inc. (HELCO)

Hawaii Leads as First State to Establish a 100% Renewable Energy Portfolio Standard

- Governor David Ige signed an expanded RPS into law in June 2015. Key milestones are shown below (see chart lower left).
- Renewable generation produced by the utility, independent power producers, and customer-sited, grid-connected sources (e.g., rooftop PV systems) may be counted toward RPS requirements.
- In addition, Hawaiian Electric Companies may aggregate their renewable portfolios in order to meet RPS requirements.
- According to a recent PUC report, both the Hawaiian Electric Companies and KIUC are highly likely to achieve the 30% RPS in 2020. Further, the 40% RPS in 2030 is achievable with the addition of reasonably expected amounts of utility-scale and distributed renewables.
- The PUC also notes that costs of renewable energy projects under development and recently proposed are below the cost of most fossil-fuel generation, which is primarily oil-fired.
- With high-avoided electricity costs tied to petroleum prices, a marked increase in the use of renewables is expected to reduce the costs paid by electricity customers in the future. For reference, avoided costs for the Hawaiian Electric Companies recently ranged from $0.12/kWh to $0.28/kWh, depending on the island.

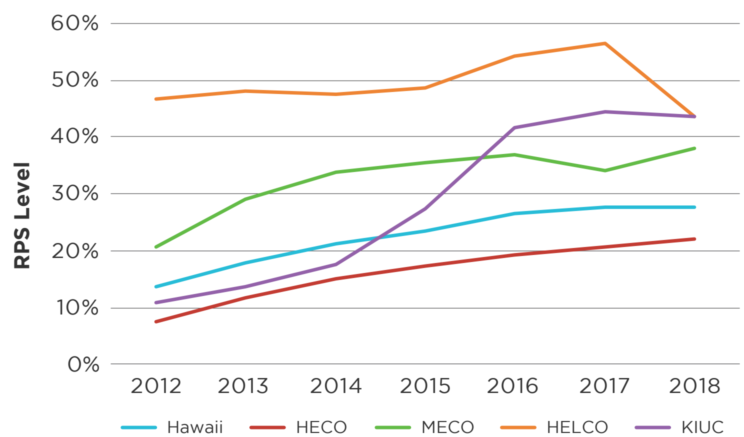
Hawaii RPS Targets and Actual RPS Compliance (as % of Retail Sales)



Note: Requirement by year-end.

Source: Hawaii State Energy Office

Hawaii RPS Compliance by Utility and Statewide (2012–2018) (as % of Retail Sales)



Note: HELCO's notable decline in renewable energy production is due to a lava eruption event closing a 38 MW geothermal facility.

Sources: Hawaii State Energy Office; EIA

KEY TAKEAWAYS

- In June 2015, Hawaii became the first state to mandate a 100% RPS by 2045. The state is expected to succeed in meeting an interim goal of 30% by 2020.
- This bold vision is forcing regulators and electric utilities to adopt new paradigms impacting planning, procurement, operations, and utility business models.
- The broad range of efforts includes defining integrated grid planning methodologies, transitioning away from traditional net energy metering, dispatching solar plus storage in evening hours, and establishing performance-based ratemaking.
- These systemic changes lay the foundation for the state to achieve high penetrations of utility-scale and distributed renewable resources in the future.

Paradigm Shift: Hawaii's New Approaches to a Changing Grid Environment

Business Function	Electric Utility	Old Paradigm	New Paradigm	Description
Planning	Hawaiian Electric Companies	Smart Grid upgrades	Grid modernization strategy	▪ Provides a detailed analysis and plan for integrating DERs
		Power supply improvement plan (e.g., IRP)	Integrated grid planning	▪ Establishes a holistic framework for planning generation, transmission, and distribution
		No connection to transportation sector	Electrification of transportation strategic roadmap	▪ Outlines how the utility can accelerate the adoption of electric vehicles
Procurement	Hawaiian Electric Companies	Retail net energy metering	Customer Grid Supply Plus and Smart Export programs	▪ Leverages smart inverters to curtail customer rooftop solar or uses battery storage to ensure excess electricity is exported during evening and overnight hours
		Energy-only renewable PPA	Renewable dispatchable generation PPA	▪ Allows a utility to dispatch generation below potential output in return for energy payments and/or monthly lump sum payments to developer/owner
Operations	KIUC	Dispatchable fossil generation	Dispatchable solar plus storage	▪ Leverages battery storage to dispatch solar production and enhance overall value to grid
Utility Business Model	Hawaiian Electric Companies	Cost-of-service ratemaking	Performance-based ratemaking	▪ Aligns a utility's interest with clean energy goals and customer preferences

New Paradigms Span Business Functions and Electric Utilities

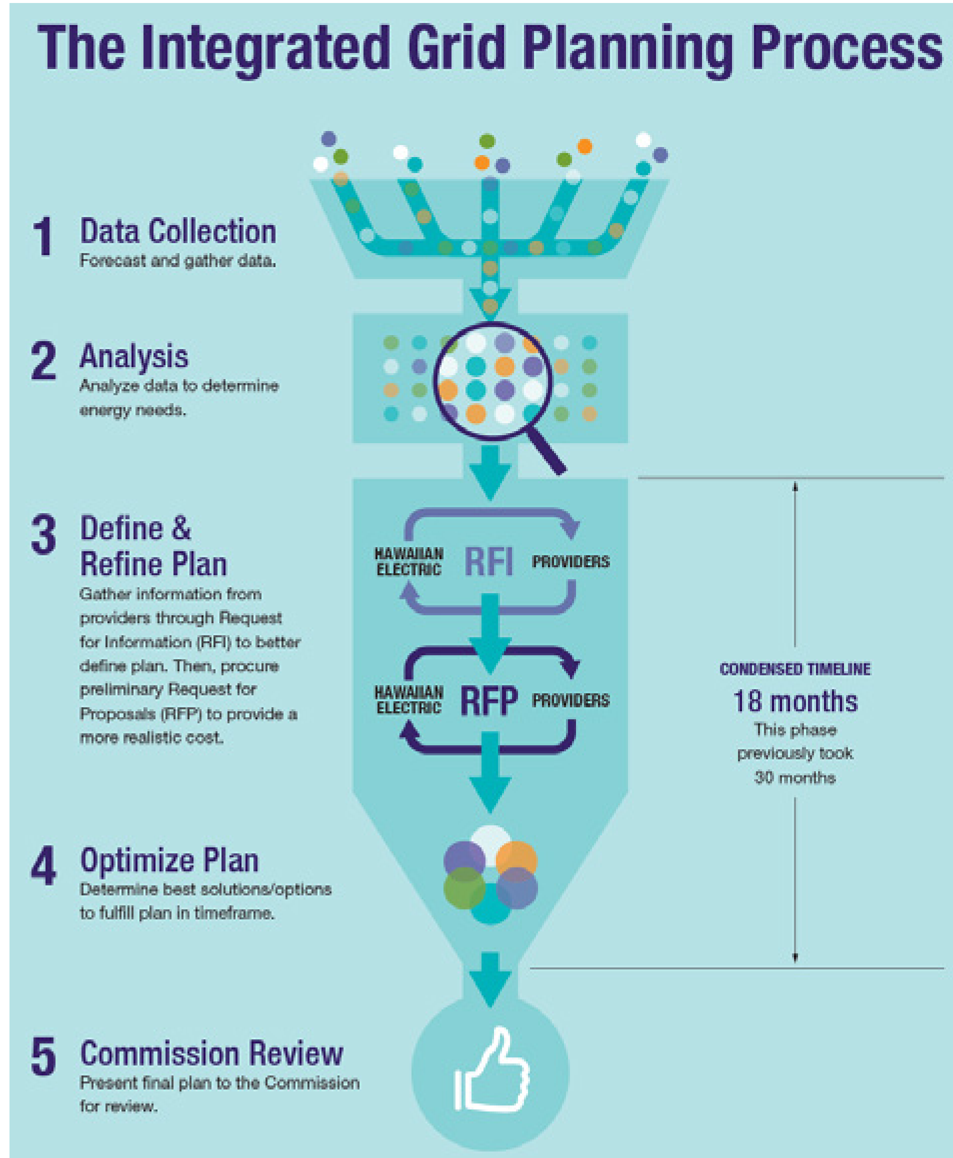
- The comprehensive changes being undertaken in Hawaii span four business functions: planning, procurement, operations, and utility business model (see table above).
- While each initiative may contain an interesting story, the collective effort is a notable shift to transform the state's electric sector.
- Each business function is discussed in more detail on the following pages.

New Planning Initiatives from Hawaiian Electric Companies Offer a Holistic View While Detailing Near-Term Actions

- The Hawaii PUC has mandated that the utility implement a grid modernization strategy that prioritizes and sequences investments designed to maximize flexibility, minimizes redundancy and obsolescence, and enables DER and renewable energy integration.
  - In January 2017, the PUC dismissed an application by Hawaiian Electric Companies for a Smart Grid foundations project and directed the utility to develop a "well-vetted and detailed strategy" for grid modernization.

- The ensuing plan, approved in February 2018, strives in the near term to use advanced grid technologies on the distribution system to enable cost-effective DER integration and utilization.
- Proposed expenditures will be categorized by their main purpose: standards and safety compliance, policy compliance, net benefits to customers, and self-supporting (e.g., paid for directly by customers participating in DER programs).
- In March 2019, the PUC approved $86 million to be invested between 2019 and 2023 in three main technologies: advanced meters, a meter data management system, and a telecommunications network.

- As part of the grid modernization strategy, the utility proposed an integrated grid planning (IGP) process as a way to integrate needs at all levels of the system: bulk power resources, transmission, distribution, and customer.
  - Approved by the PUC in March 2019, the IGP streamlines traditionally disparate and serial planning and procurement tasks into a unified process (see graphic at right).
  - The IGP process is expected to produce a five-year plan in June 2021, detailing discrete investments, programs, and pricing proposals.
- An electrification of transportation strategic roadmap, released in March 2019, outlines how the utility may accelerate electric vehicle adoption.
  - The roadmap found that shifting a portion of unmanaged evening charging to workplace charging can result in significant benefits for electric customers.
  - The benefit comes from the increasing amount of low-cost solar that can be integrated into the electricity supply and by avoiding distribution upgrades that would otherwise be needed to support evening charging.
- Within the regulatory environment, there is clear connectivity and cohesion between regulatory dockets and a strong focus on stakeholder engagement and near-term work plans. Unlike states with multiple electric utilities, the Hawaii PUC may benefit from the focused oversight of a single investor-owned utility (i.e., Hawaiian Electric Companies) serving 95% of the state's population.



Source: Hawaiian Electric Companies

Hawaiian Electric Companies Think Outside the Box for Procurement of Distributed and Utility-Scale Renewables

- Since the 2015 termination of net energy metering, the Hawaiian Electric Companies continue to refine programs that encourage deployment of DERs.
  - More than 60,000 customers installed solar under the original net energy metering program before it was closed by the Hawaii PUC.
  - A successor tariff, called Customer Grid Supply, offered lower rates for excess electricity, but it reached program capacity in just over two years.
  - Today, the utility offers two programs for new distributed generation:
    - **Customer Grid Supply Plus:** Compensates controllable DERs for excess energy exported to the grid, unless grid conditions require a reduction in output.
    - **Smart Export:** Promotes storage by providing no compensation for mid-day exports, but enhanced compensation during evening and overnight hours.
- Hawaiian Electric Companies have also deployed an innovative renewable dispatchable generation (RDG) PPA in their procurement of utility-scale renewables.
  - The deal structure provides the option for payments in two parts: a monthly lump-sum component to cover fixed costs and a price for purchase of electric energy to cover variable O&M costs. The seller under the PPA may also rely solely on either monthly lump-sum payments or per MWh energy payments.
  - Under the contract's terms, the utility may control and dispatch the system (even at levels below the potential output available), while renewable systems must meet performance and availability metrics.
  - In a recent proposal request using the RDG PPA, the majority of PPAs relied solely on lump-sum payments, thereby foregoing traditional energy payments.
  - Developers find the setup attractive because the lump-sum payment removes the financial risk associated with curtailment.

> **"It is abudantly clear that distributed energy resources can provide benefits to Hawaii. It is also clear, for both technical and economic reasons, that the policies established more than a decade ago must be adapted to address the reality of distributed energy resources as they exist today—and as they are likely to develop in the near future. The challenge facing the State now is ensuring that DER continues to scale in such a way that it benefits all customers as each utility advances towards 100% renewable energy."**
>
> \- Hawaii Public Utilities Commission on net energy metering cap (Order No. 33258, Docket No. 2014-0192)

Hawaiian Electric Companies Sign RDG PPAs with Seven Solar-Plus-Storage Projects

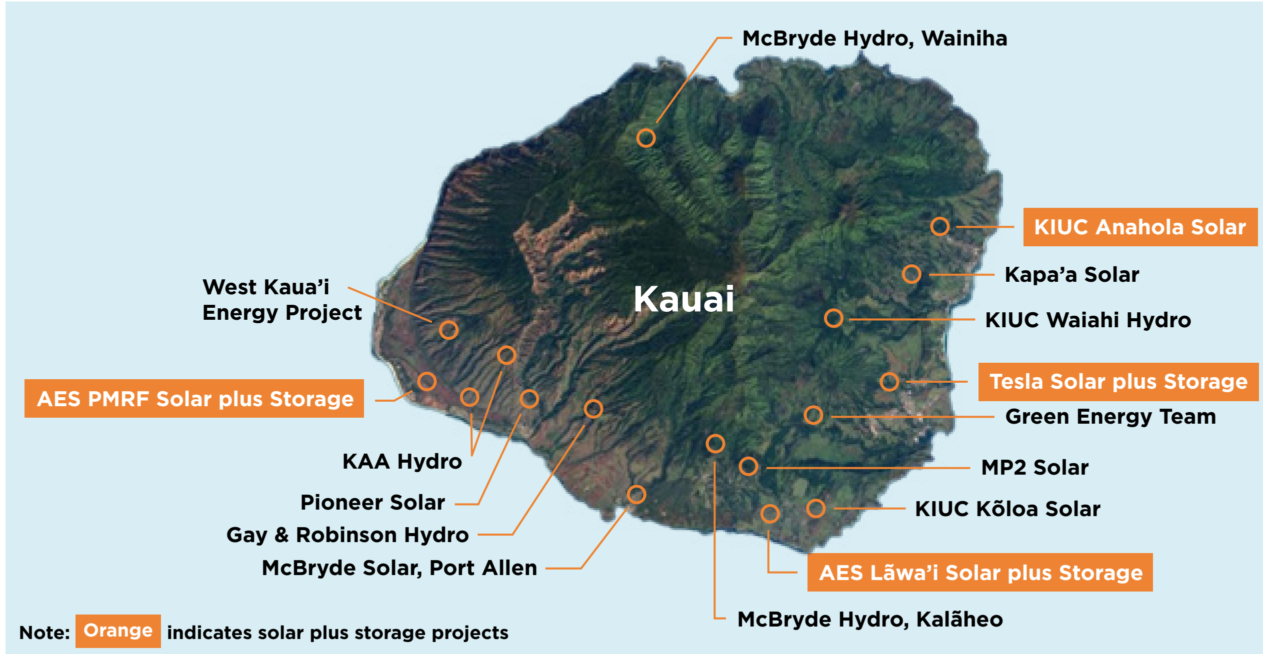
Project Name	Island	Developer	Size	Storage	Cost per kWh
Waikoloa Solar	Hawaii	AES	30 MW	120 MWh	$0.08
Hale Kuawehi	Hawaii	Innergex	30 MW	120 MWh	$0.09
Kuihelani Solar	Maui	AES	60 MW	240 MWh	$0.08
Paeahu Solar	Maui	Innergex	15 MW	60 MWh	$0.12
Hoohana	Oahu	174 Power Global	52 MW	208 MWh	$0.10
Mililani I Solar	Oahu	Clearway	39 MW	156 MWh	$0.09
Waiawa Solar	Oahu	Clearway	36 MW	144 MWh	$0.10

Source: HECO

KIUC Uses Solar Plus Storage to Enhance Operations, Yet More Work Remains

- With renewables accounting for 55% of generation in the first half of 2019, KIUC is the furthest along toward meeting Hawaii's long-term renewable energy targets. KIUC is subject to Hawaii's 100% renewable mandate.
- Part of its success can be attributed to reliance on utility-scale renewables. For example, more than three-quarters of solar generation came from utility-scale systems in 2018.
- Even more importantly, KIUC has an extensive and growing track record with solar plus storage systems.
- Key innovations include leveraging a battery energy storage system to provide ancillary services and designing a solar plus storage system to dispatch energy during evening peak.
- But the growing dependency on renewables, even with storage, still requires some thermal generation for support. In July 2019, a forced outage of the island's largest (fossil) generator—coupled with cloudy weather—stressed the still limited solar plus storage capacity and resulted in several days of rolling blackouts.
- ScottMadden and the Smart Electric Power Alliance hope to hear about the lessons learned from the event during an upcoming fact-finding mission to Hawaii.

KIUC: Abundant Renewables Development with Solar Plus Storage Gaining Traction



Selected Solar Plus Storage Projects

KIUC Anahola Project	Tesla Solar Plus Storage	AES Lāwa'i Solar
Key Statistics: ▪ COD: October 2015 ▪ Solar Capacity: 12 MW-ac ▪ Storage Capacity: 6 MW ▪ PPA Pricing: $0.128/kWh	**Key Statistics:** ▪ COD: March 2017 ▪ Solar Capacity: 13 MW-ac ▪ Storage Capacity: 13 MW/52 MWh ▪ PPA Pricing: $0.139/kWh	**Key Statistics:** ▪ COD: April 2019 ▪ Solar Capacity: 20 MW-ac ▪ Storage Capacity: 20 MW/100 MWh ▪ PPA Pricing: $0.1108/kWh
Notable Feature: Storage system designed to provide frequency support, voltage regulation, and energy reserve functions for the grid	**Notable Feature:** Facility believed to be first utility-scale solar system in the United States with the ability to provide dispatchable solar energy to the grid hours after sundown	**Notable Feature:** World's largest operational solar plus storage system

Source: Hawaii State Energy Office

State Legislation Requiring Performance-Based Ratemaking Changes Utility Business Model

- Passed in 2018, the Hawaii Ratepayer Protection Act requires the PUC to establish performance incentives and penalty mechanisms by January 1, 2020. The legislation exempts member-owned cooperative electric utilities and does not apply to KIUC.
- The overarching objective of performance-based ratemaking is to align the utility's business interest with Hawaii's clean energy goals and customers' preferences.
- Instead of incentivizing capital investments with traditional cost-of-service regulation, utility revenue will be based on a combination of target revenues, with the opportunity to earn additional performance revenues for achieving highly valued objectives.
- Phase 1 of the regulatory proceeding, which concluded in May 2019, produced 12 priority outcomes organized around three overarching regulatory goals (see graphic at right).
- Phase 2 of the regulatory proceeding is currently underway and focused on:
  - Updating a revenue adjustment mechanism that will establish target revenues to be applied over a five-year multi-rate period.
  - Establishing performance incentive mechanisms in the areas of interconnection experience, customer engagement, and DER asset effectiveness.

PBR Regulatory Goals and Priorities

	Goal	Priority Outcome	
1	Enhance Customer Experience	Traditional	Affordability
			Reliability
		Emergent	Interconnection Experience
			Customer Engagement
2	Improve Utility Performance	Traditional	Cost Control
		Emergent	DER Asset Effectiveness
			Grid Investment Efficiency
3	Advance Societal Outcomes	Traditional	Capital Formation
			Customer Equity
		Emergent	GHG Reduction
			Electrification of Transportation
			Resilience

Source: Hawaii PUC

IMPLICATIONS

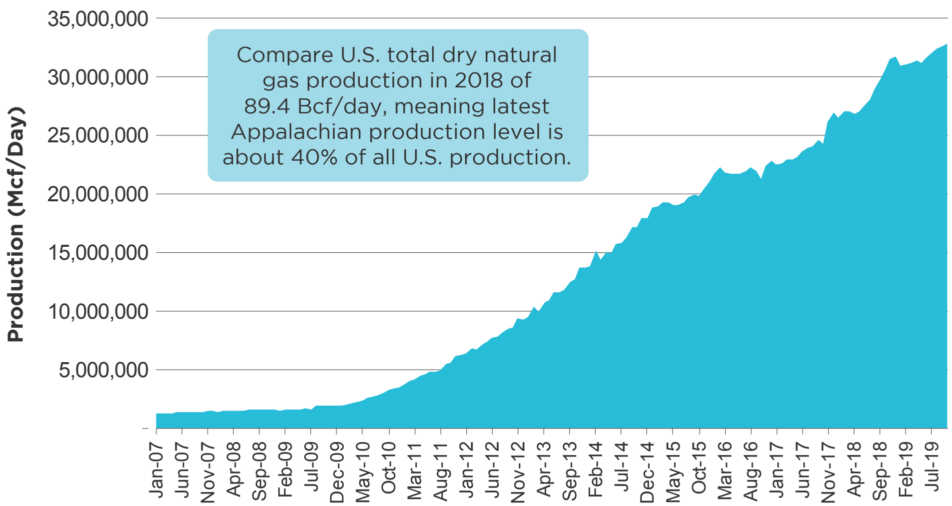
While regulatory reforms in California and New York continue to receive a great deal of attention, there are considerable—and often overlooked—efforts underway in the state of Hawaii. The goal of 100% renewable energy by 2045 is a clear driver pushing new paradigms. While initiatives, such as performance-based ratemaking, are being pursued in other states, efforts such as the RDG PPA are unique to Hawaii. Hawaii clearly remains a unique test laboratory to watch for both lessons learned—and new ideas.

Sources: K. Kaufmann, John Pang, John Sterling, and Chris Vlahoplus, "Postcards from Hawaii: Lessons on Grid Transformation," *Public Utilities Fortnightly* (Feb. 2016), available at https://www.fortnightly.com/fortnightly/2016/02/postcards-hawaii-lessons-grid-transformation; Hawaii Public Utilities Commission; Hawaii State Energy Office, Hawaii Energy Facts & Figures (July 2019); utility websites; industry news; various regulatory dockets.

THE ENERGY INDUSTRY IN CHARTS

Marcellus and Utica Shale Continues to Be Prolific, As Takeaway Capacity Expands

Monthly Natural Gas Production (Mcf/Day) in Appalachia (incl. Marcellus and Utica Shale Plays) (Jan. 2007–Aug. 2019)



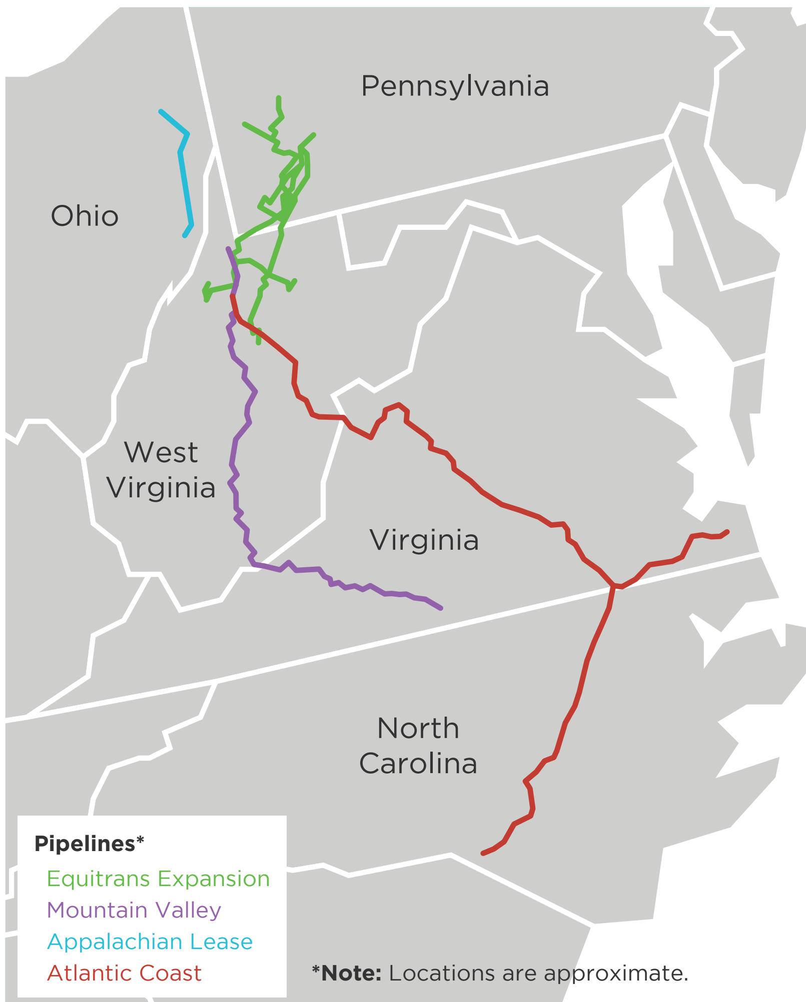
Source: EIA

Selected Northeastern Pipeline Projects (as of July 31, 2019)

Project	Operator	Expected Year in Service	Additional Capacity (MMcf/Day)
Appalachian Lease Project (TEAL) Phase 2	Texas Eastern Transmission	Completed	313
Equitrans Expansion Project	Equitrans LP	2019	600
Atlantic Coast Pipeline	Atlantic Coast Pipeline	2020	1,500
Mountain Valley Pipeline	Mountain Valley Pipeline, LLC	2020	2,000
Supply Header Project	Dominion Transmission	2020	1,500
Northeast Supply Enhancement	Transcontinental Gas Pipeline	2021	400
Leidy South Project	Williams Pipeline	2022	582
Regional Energy Access Project (Phases I and II)	Transcontinental Gas Pipeline	2022	1,050

Sources: EIA; ScottMadden research

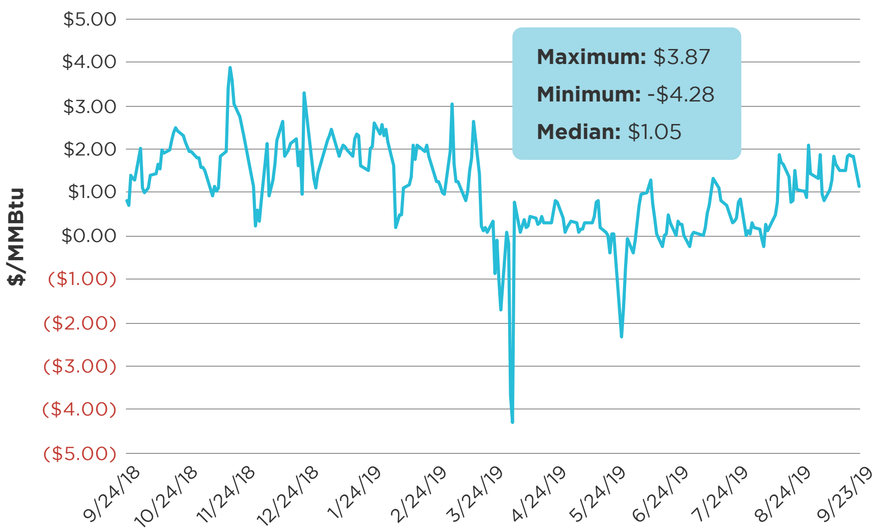
Increasing Takeaway Capacity to Move Abundant Appalachian Gas Production: Selected Recently Completed and Under Construction Natural Gas Pipelines in the Northeastern United States (as of July 31, 2019)



Source: EIA

Trapped Permian Production Creates Dirt-Cheap Natural Gas Prices

Waha Hub (West Texas) Spot Natural Gas Prices (Sept. 24, 2018–Sept. 23, 2019) (in $/MMBtu)



Gas as cheap as a cup o' joe, but with nowhere to go.

National average usage: 63.5 MMBtu/ residential customer → $1.05 median Waha hub price → ~$67/year **OR** $5.56/month

About 2X Starbucks® venti coffee (~$2.35 ea.)/month

Highest regional usage (IL): 95.1 MMBtu/ residential customer → $1.05 median Waha hub price → ~$100/year **OR** $8.32/month

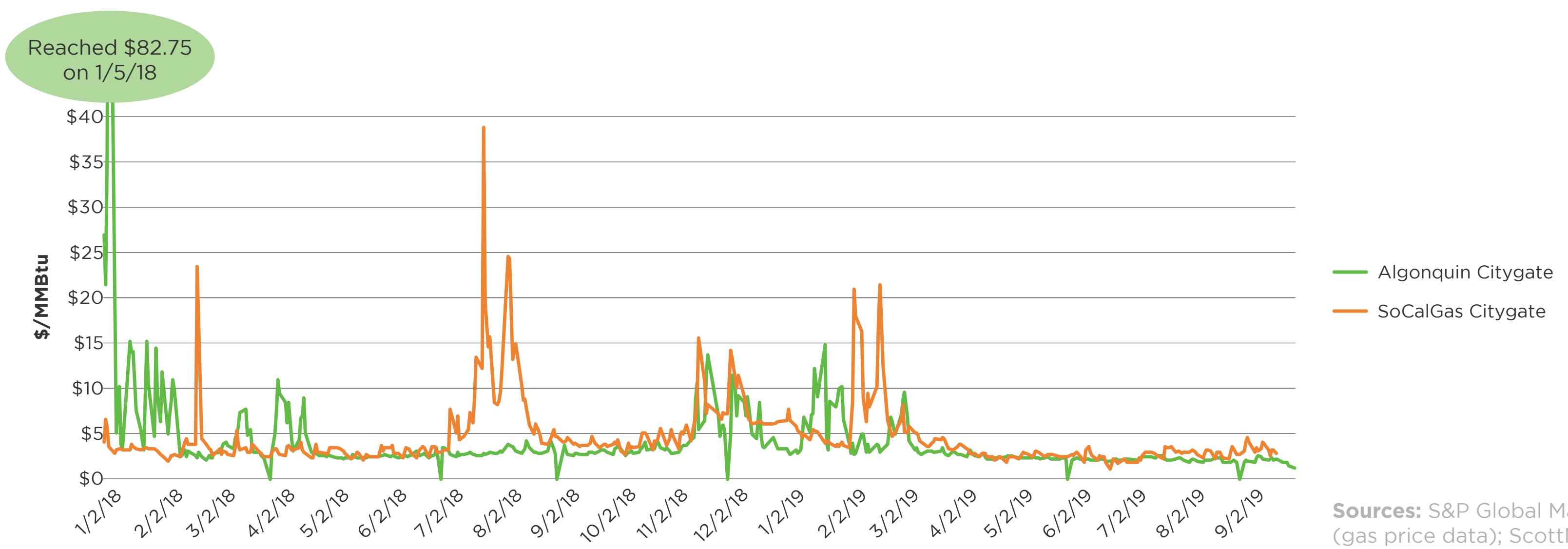
About 2X Starbucks® grande mocha (~$3.95 ea.)/month

Abundant gas production in the Permian basin has created cheap natural gas prices, as takeaway capacity is currently inadequate. During the first eight months of 2019, the Waha spot price averaged just 65¢ per MMBtu. **That situation may be reversing as new pipeline capacity, such as the 2 BCF/Day Gulf Coast Express Pipeline, begins operation.**

Sources: S&P Global Market Intelligence (gas price data); American Gas Association (usage data); ScottMadden analysis

Location Matters: While Supply Areas Are Flush, Some Market Areas Still See High and Volatile Prices

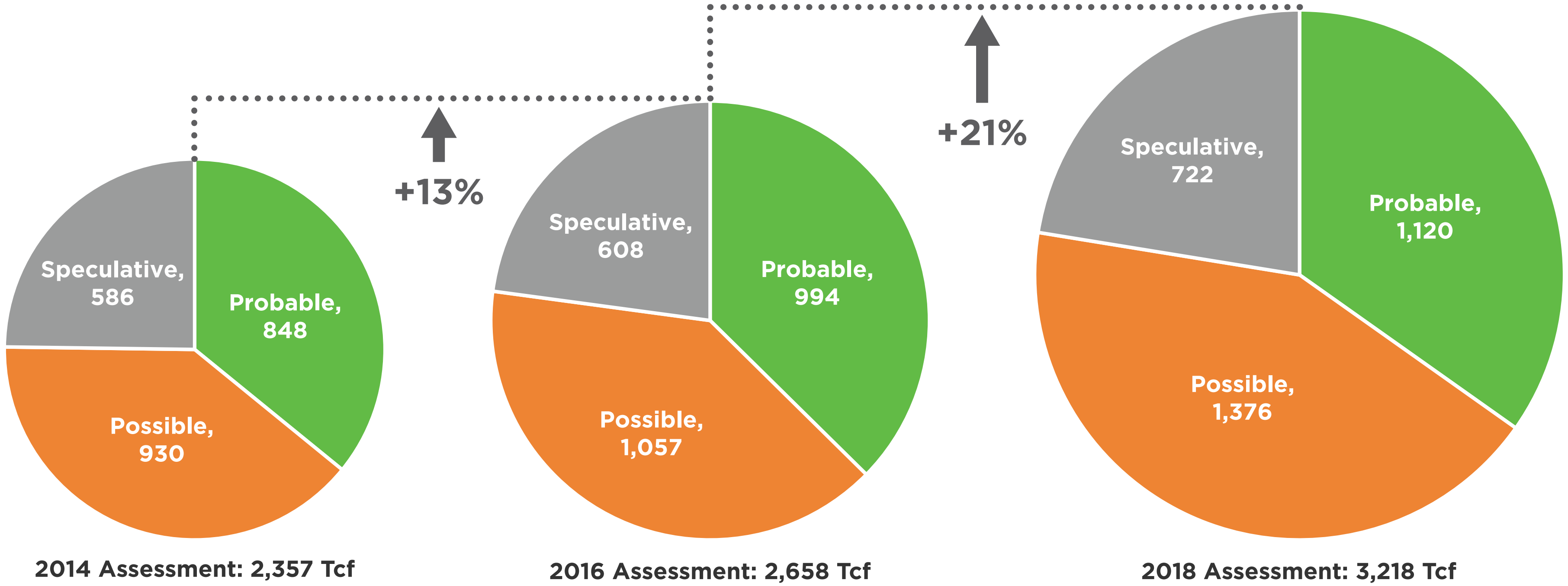
Algonquin Citygate (MA) and SoCalGas Citygate (CA) Spot Natural Gas Prices (Jan. 2018–Sept. 2019) (in $/MMBtu)



Sources: S&P Global Market Intelligence (gas price data); ScottMadden analysis

Gas Resources Continue to Grow

Growing Resources: Mean, Technically Recoverable Potential Traditional U.S. Natural Gas Resources (Conventional, Tight, and Shale Reservoirs) (in Tcf)*



*Figures may not sum to total because of independent rounding. 2014 total value is derived by separate statistical aggregation and not by arithmetic summation of Probable, Possible, and Speculative Resource values.

Notes: Excludes coalbed gas resources. Potential resources include all undiscovered gas resources plus that part of the discovered resources which is not included in proved reserves. While technically recoverable, the resources might not be economically recoverable. Probable resources are associated with known fields and are the most assured of potential supplies. Possible resources are a less assured supply because they are postulated to exist outside known fields, but they are associated with a productive formation in a productive province. Speculative resources, the most nebulous category, are expected to be found in formations or geologic provinces that have not yet proven productive.

Sources: Potential Gas Committee of the United States, Potential Supply of Natural Gas in the United States (as of Dec. 31, 2014) (Apr. 2015) and (as of Dec. 31, 2018) (Sept. 2019)

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GLOSSARY

Bcf
billion cubic feet

CAISO
California ISO

CCS
carbon capture and storage

CO_2
carbon dioxide

COD
commercial operation date

DER
distributed energy resource

DOE
U.S. Department of Energy

EIA
U.S. Energy Information Administration

GHG
greenhouse gas

$GtCO_2$
gigatons CO_2

GW
gigawatt

GWh
gigawatt-hour

IEA
International Energy Agency

IPCC
Intergovernmental Panel on Climate Change

IRP
integrated resource plan

ISO
independent system operator

kW
kilowatt

kWh
kilowatt-hour

Mcf
thousand cubic feet

MMcf
million cubic feet

MMBtu
million British thermal units

$MtCO_2e$
million metric tons CO_2-equivalent

Mtpy
million metric tons per year

MW-ac
megawatt-AC

MW
megawatt

MWe
megawatt electric

MWh
megawatt-hour

MWt
megawatt thermal

O&M
operations and maintenance

PPA
power purchase agreement

PUC
Public Utilities Commission

PV
photovoltaic

RPS
renewable portfolio standard

RTO
regional transmission organization

SPP
Southwest Power Pool

Tcf
trillion cubic feet

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Grid Edge	▪ California Defines a More Standardized Approach for Cost-Benefit Analysis of Distributed Energy Resources that Includes Cost of Carbon Values ▪ New York Energy Storage Order ▪ Charging Up: A Review of Electric Vehicle Workplace Charging
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ENERGY PRACTICE
SCOTTMADDEN KNOWS ENERGY

About ScottMadden

We know energy from the ground up. Since 1983, we have served as energy consultants for hundreds of utilities, large and small, including all of the top 20. We focus on Transmission & Distribution, the Grid Edge, Generation, Energy Markets, Rates & Regulation, Enterprise Sustainability, and Corporate Services for energy clients. Our broad, deep utility expertise is not theoretical—it is experience based. We have helped our clients develop and implement their strategies, improve critical operations, reorganize departments and entire companies, and implement myriad initiatives.

Stay Connected

ScottMadden and Smart Electric Power Alliance will take part in a fact-finding mission to Hawaii from November 3–8 to explore lessons learned navigating increasing penetrations of DERs, new regulatory approaches, and customer engagement strategies.

We look forward to presenting learnings and insights from the trip. If you are interested in receiving a copy of our key findings, please contact us at info@scottmadden.com.

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